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MODERN PUMPS FOR SMALL WATER WORKS.

BY CREED W. FULTON.

In selecting this subject, the writer has been influenced by the desire to supplement to a certain extent the excellent paper of Mr. H. A. Symonds, covering " Engines for Small Water Works," read last December, and in doing so to present certain data which may prove of both interest and value to engineers, superintendents, and operators of small water works. It is hoped that this discussion may bring forth expressions of opinions from other sources which will be of interest and value to the members of this Association.

It has been somewhat difficult to arrive at a definition of small water works, but realizing the necessity of limiting the scope of the paper, it is assumed that a small water-works plant is one where the daily consumption does not exceed 3 000 000 gal.

Under ordinary conditions as commonly found in the average small pumping plant, this would represent a maximum brake horsepower of approximately 250 h.p. This figure is based on the assumption that a 3 000 000-gal. pump will operate against a maximum pressure of approximately 150 lb.

The types of pumps discussed, therefore, will be limited to those having a capacity of 3 000 000 gal. per twenty-four hours; that is, 2 100 gal. per minute, or less.

It should be borne in mind that any deductions or conclusions reached in this discussion are intended to apply to small plants only, and necessarily might have to be modified when considered in connection with large plants.

Earlier Types of Pumps.

Before entering into a detailed discussion regarding modern types of pumps for small water works, a brief summary touching the high points in the development of pumping machinery may prove of interest.

The first really modern and successful water-works pump was the direct-acting steam pump. It was nearly eighty years ago — 1840, to be exact — when Henry R. Worthington began his series of brilliant inventions which led to most of the modern forms of steam pumps.

One of the first steam water-works pumps was erected about 1854 for the city of Savannah. It was a compound machine of peculiar design as regards the arrangement of the high- and low-pressure cylinders, but it was a success and was followed by similar pumps for the city of Cambridge, Mass.

The year 1859 marked the introduction of the Duplex pump, which was for years the standard type of pumping engine. Various improvements followed as a result of the efforts of such men as Blake, Knowles, Cameron, Marsh, Dean, and others.

The use of steam pumps on a large scale began about the year 1860. Shortly after this, the Cornish engine made its entry, followed by several other vertical pumping engines of various designs.

The crank and fly-wheel pump appeared about 1868. Various other improvements followed shortly, these being principally improvements in the detail of mechanism. No really fundamental changes in design occurred until about 1876, when the Corliss pumping engine made its first appearance and proved to be a great success.

Steam was now being used expansively with a marked increase in economy. Duties, by this time, had risen from around 50 000 000 ft.-lb. per 100 lbs. of coal, to around 120 000 000 ft.-lb. per 100 lb. of coal.

The Holly Manufacturing Company followed up the Corliss invention with a special water-works pump which proved very successful, and which has, with certain modifications, been used ever since. Numerous other makes and types made their appearance, and the steam pump continued in use with increasing force up to within the last fifteen or twenty years.

It was quite logical that the steam pump should enjoy this period of intensive development and use. By so doing, it was following, step by step, the development of the steam engine — then the chief prime mover or source of power. It should be kept in mind at this point that the development of pumps has always been directly and greatly influenced by power-plant development, and just as the original steam pump followed the development and improvements in the steam engine, so the present-day pumps are the outgrowth of new tendencies in power-plant development.

Recent Tendencies.

Within the past fifteen or twenty years, new tendencies, however, have asserted themselves, resulting in a marked change in power-plant development.

The isolated power plant has given way rapidly, and very generally, to the central station. The development of the steam turbine and improvements in the design of electrical machinery have made possible and successful central stations of enormous capacity, with transmission systems of almost unlimited scope.

As a result, we have witnessed the gradual electrification of factories, trolley lines, railroads, and, of particular interest to this meeting, water works.

This change has been forced by basic economic factors, the chief one being the economies made possible by the consolidation of a large number of small steam plants into one large central station. The reasons for, and the results of, this consolidation are familiar to almost every one to-day.

Students and observers of power developments generally agree that the future will witness the continued consolidation of power plants — that even larger central stations will be the rule, with marked accompanying development in transmission systems linked together and covering the entire country.

How has this power-plant development affected water-works plants? One thing is certain, and that is, it has affected and will continue to affect chiefly the smaller plants. The larger water works were the first to utilize the steam pump, and they will undoubtedly continue to use them to good advantage for years to come; but it is obvious that the direct-acting steam pump is passing away as far as its use in small plants is concerned. Not only is the fuel or power cost too high, but such an installation in a small plant involves the problem of a licensed engineer and certain other unfavorable factors which mitigate against its use in these modern days.

This statement should not be interpreted as meaning that steam pumps of any kind are not to be considered in small plants. The crank and fly-wheel pump, the turbine-driven centrifugal pump, and the recently developed Una flow, steam pumpimg engine will under certain conditions prove acceptable units. In the main, however, for pumps of less than 3 000 000-gal. capacity, the tendency is to get away from steam as the driving power.

One reason for this is that the first cost of such installations is often so high that the fixed charges offset the difference in economy, in addition to which the labor requirements are usually rather severe.

Only under peculiarly favorable conditions could a steam-driven plant compete with a modern plant equipped with electrically driven or internal-combustion engine driven pumps for capacities of 3 000 000 gal. or less.

There are, of course, many instances in small plants where modern pumps are driven from steam engines, steam turbines, water wheels, etc., but such instances usually occur in old plants where the physical condition of the pumps makes replacement necessary; but for one reason or another the old source of power has to be retained in its original, or at best, a slightly modified form.

This tendency to get away from steam pumps in small plants has been accentuated by the development and perfection of the internal combustion engine. The highly perfected Diesel or semi-Diesel type of oil engine is admirably adapted for driving reciprocating pumps where high duties are desired. This combination of pump and engine has been used very suc-

cessfully in a large number of plants ranging in capacities from one million to four or five million gallons per day.

The perfection of the gas producer and gas engine has likewise made it possible to successfully use a combination of gas producer, gas engine, and reciprocating or centrifugal pump to good advantage. The development of the modified Diesel, commonly known as "semi-Diesel" engine has provided a moderately priced yet comparatively high-duty internal-combustion engine which is very attractive, particularly in small plants.

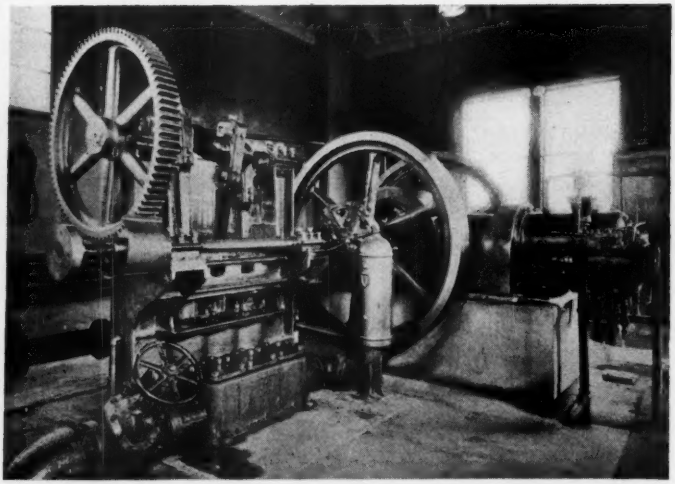


FIG. 1. VERTICAL SINGLE-ACTING TRIPLEX PLUNGER PUMP DIRECT CONNECTED TO DE LA VERGNE OIL ENGINE. WATERWORKS, TOWN OF SHREWSBURY, MASS.

A combined unit of this type is very desirable for small water works. It combines simplicity, compactness, and high economy, with complete reliability. As no power is required from outside sources, the engine and pump being a complete power plant in themselves, there is no danger from possible shut-downs such as is sometimes the case where electric lines have to be carried a great distance from the source of supply to the pumping station. The pump illustrated above is an 8 x 10 in. triplex plunger pump with a capacity of 300 gal. per minute against 150 lb. discharge pressure. The pump is connected to a 35 h.p. De La Vergne oil engine.

The latest and most apparent tendency in small water-works plants is the use of pumps deriving their power from independent or outside sources. There are to-day two types of power units especially applicable to modern pumps for small water works. They are: (*a*) The electric motor and (*b*) the internal combustion engine. Under the latter heading we may class the gas engine, using either natural, illuminating, or producer gas, and the fuel oil or distillate engine.

It is not the intention of this paper to discuss in detail the design and construction of engines or power units for driving modern pumps. This

matter is covered in excellent shape by the paper presented by Mr. H. A. Symonds at the meeting of this Association on the 12th of December, 1918. The discussion will, therefore, cover primarily the types of modern pumps, general features of design and construction, adaptability to various conditions, relative economy, and the proper selection, installation, and operation of the same.

Modern Pumps.

The modern pump for small water works will ordinarily be one of two general types: (*a*) reciprocating, or (*b*) centrifugal.

The name "reciprocating pump" covers all pumps in which the water is displaced either by a plunger, piston, or bucket, working back and forth in a cylinder.

Reciprocating pumps are generally classified in several ways:

(*a*) In regard to the plane in which the plungers or pistons move (vertical or horizontal).

(*b*) In regard to the number of displacements (single acting or double acting).

(*c*) In regard to the number of cylinders.

(*d*) In regard to the manner of packing.

(*e*) In regard to the form or kind of displacer (plungers or pistons).

For example, a type of reciprocating pump common to small water works is the vertical single-acting, triplex, outside-packed plunger pump. (See Fig. 1.) Another familiar type of reciprocating pump is the vertical double-acting, triplex piston pump. (See Fig. 2.) It is not customary to refer to the way this latter type is packed, as piston pumps are essentially inside-packed pumps.

In the horizontal type of reciprocating pump the pump may be of the single- or double-acting plunger type, either outside center packed, or outside end packed. (See Fig. 3.) This horizontal type of machine is most apt to be used for larger capacities or heavier duty.

Characteristics of Reciprocating Pumps.

The reciprocating pump has characteristics which are commonly known to every one on account of the length of time that pumps of this kind have been in use.

A reciprocating pump is known as a positive displacement pump for the reason that the water that is discharged from the pump is actually displaced by a plunger, piston, or bucket. It is obvious, therefore, that for any given size of reciprocating pump the capacity of the pump depends on the speed at which it is run. Capacity is, therefore, directly proportional to the speed in any reciprocating pump. This is theoretically true, and almost practically true, the only modification of this rule being caused by a

slight difference in the slip of a pump through the valves, depending upon the speed and suction lift. Usually the slip is greater as the speed and suction lift become greater.

A reciprocating pump will operate against any head from zero head up to the maximum head for which the pump is designed, and will deliver any capacity within the range of the pump by simply selecting the proper speed to give the capacity. In other words, the head which the pump develops is not a function of the speed, as is the case in a centrifugal pump.

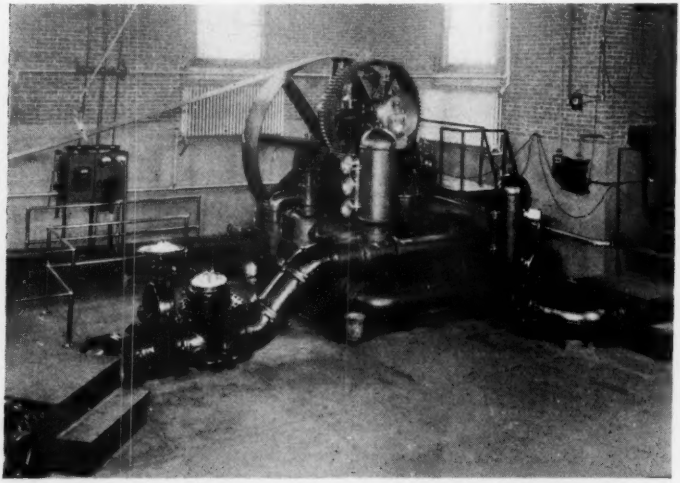


FIG. 2. VERTICAL DOUBLE-ACTING TRIPLEX PISTON PUMP. WATER WORKS, TOWN OF NORWOOD, MASS.

This type of pump is in large use in small water works. The particular unit shown above is belt driven from a 200 h.p. motor. The pump has a capacity of 2 000 000 gal. of water in twenty-four hours against a total net head of 350 ft. Pump of this type will show an efficiency of from 85 per cent. to 90 per cent. under the operating conditions specified. This makes a thoroughly reliable unit for hard, steady service.

The power consumed by a reciprocating pump is directly proportional to the product of the capacity in gallons per minute, and the head in feet. A rule commonly used by those having to do with pumps is to figure the horsepower by the following formula:

$$\text{h.p.} = \text{capacity in gallons per minute} \times \text{total head in feet}, \div 3\,960.$$

For the sake of simplicity most pump men use 4 000 as a divisor instead of 3 960. For example, the theoretical horsepower required by a pump delivering 500 gal. per minute against 200 ft. head would be $500 \times 200 \div 4\,000 = 25$ h.p.

In order to obtain the actual brake horsepower required to drive the pump, the theoretical horsepower is divided by the efficiency of the pump.

For example, the ordinary reciprocating pump will have an efficiency somewhere between 65 per cent. and 88 per cent. Assuming, therefore, a pump for the capacity and head outlined above, under which conditions the theoretical horsepower would be 25, and assuming that this pump had an efficiency of 80 per cent., then the brake horsepower required to operate the pump would be $25 \div .80 = 31.3$ brake horsepower.

The efficiency of any reciprocating pump varies, depending on the speed and head against which the pump operates. For example, suppose a pump designed for a normal capacity of 1 000 gal. per minute against a total net head of 300 ft. is being operated at its normal rating, — that is,

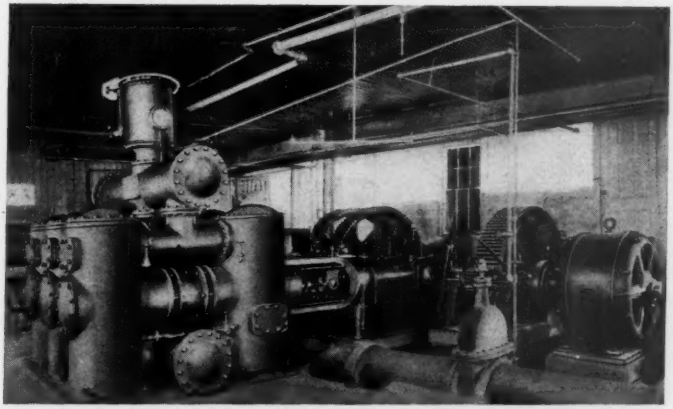


FIG. 3. HORIZONTAL DOUBLE-ACTING CENTER-PACKED PLUNGER PUMP. WATERWORKS, CITY OF COHOES, N. Y.

The particular unit illustrated above is interesting as it shows a possible arrangement for direct connection both to a motor and to a water wheel. This pump is arranged for operating from both sources of power. Pump has a capacity of about 3 000 000 gal. in twenty-four hours against 100 lb. discharge pressure. Pumps of this type give extremely good efficiency when operating at full load; efficiency being around 85 per cent. to 90 per cent. for the conditions specified above.

100 per cent. rating. Under these conditions, a pump of this kind would ordinarily have an efficiency of around 85 per cent.

Now, if this pump should be slowed down and run at a capacity of only 750 gal. per minute against the same head, the efficiency would drop off. There is no exact rule which can be used to figure the variation in the efficiency under such conditions. The efficiency curves (Fig. 4), as shown herewith, illustrate the general shape of the efficiency curve and the effect which variation in capacity, speed, or head will have on any reciprocating pump. Generally speaking, the efficiency is greatest when the pump is operated at 100 per cent. rating or slightly more. If the head or capacity, either, is decreased below 100 per cent., the efficiency will fall off, following, generally, the course outlined by the efficiency curves which are herewith shown.

Centrifugal Pumps.

The centrifugal pump of to-day is a development of the last twenty years. Although 1680 is the year given when the first centrifugal pump was built, and 1818 the year when the first crude pump of this type (called the

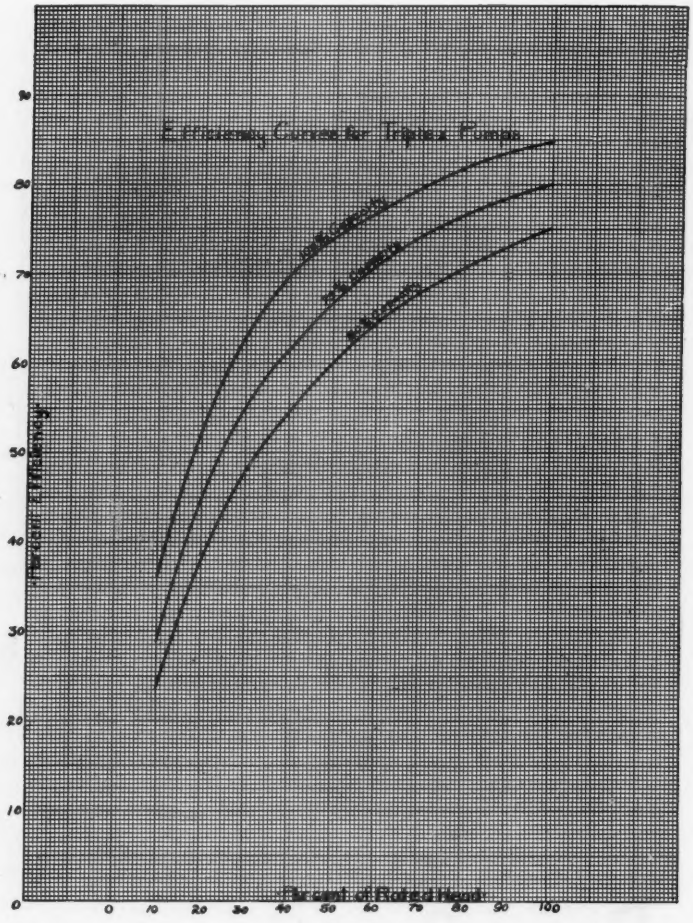


Fig. 4.

"Massachusetts pump") was built in this country, it was not until recent years that this type of machine was considered seriously. It was due probably to the fact that a centrifugal pump is a relatively high-speed machine, and there was no motive power well suited to it.

With the introduction of the electric motor and steam turbine, con-

ditions have changed. These high-speed machines stimulated the development of the centrifugal pump, and we now find an ever-increasing demand for this type of pumping machinery.

Pumps that depend for their action upon centrifugal force or the variation of pressure due to rotation, are termed "centrifugal pumps." Other factors, however, have an important effect, as will be shown later.

Classification of Centrifugal Pumps.

Centrifugal pumps may be divided generally into two classes: (*a*) volute pumps, (*b*) turbine pumps.

A volute pump is one in which there are no diffusion or guide vanes, but instead the casing is spiral in shape. The casing may be considered as a great guide vane.

The effect of this spiral, sometimes called "volute," is the production of an equal velocity of flow at all sections around the circumference of the casing, and the velocity of the water, as it leaves the impeller, is gradually converted into pressure as it flows to the discharge pipe.

A turbine pump is one in which the impeller is surrounded by a circular plate or diffuser which contains ribs forming water passages, sometimes called "guide vanes." These vanes are so shaped that they provide gradually enlarging passages which change the velocity of the water leaving the impeller, thereby reducing the velocity head into pressure head.

Centrifugal pumps are also classified as horizontal or vertical, depending on whether the shaft operates in a horizontal or vertical position. The ordinary water-works pump is of the horizontal type.

These pumps are further referred to as "single suction" or "double suction," depending on the type of impeller which is used; that is, whether the impeller takes the suction from one side only, in which case it is single suction, or whether the impeller takes the water from both sides, in which case it is a double suction impeller.

The pump is also referred to at times by the name of "open impeller" or "enclosed impeller," but this, in classification, is of minor importance. However, enclosed impeller pumps usually develop higher efficiencies and are generally used for water-works service. (See Fig. 5.)

Theory of Centrifugal Pumps.

The theory or action of a centrifugal pump may be well illustrated by the old simile of the "boy and bucket." The boy whirls the pail of water about his head, and not a drop is spilled provided the pail is moving fast enough. The force that holds the water against the bottom of the pail is called "centrifugal force."

Now, suppose that a hole is punched in the bottom of the pail. A stream will issue forth. The stream would be continuous if the boy's arm was a pipe supplying water to the pail.

The boy's arm is a suction pipe; the pail is the impeller throwing a stream. The casing of the pump has been introduced to guide the stream in one particular direction to the discharge outlet.

Crudely, this is the story of the centrifugal pump. A word about the general principle on which centrifugal pumps work may be of interest.

Suppose there is a body — say, a pail of water on top of a house 120 ft. from the ground. Suppose it is suddenly pushed off — it would fall to the ground with an increasing speed, and it would finally strike the earth when moving at a certain rate of speed or velocity. Let us say that it

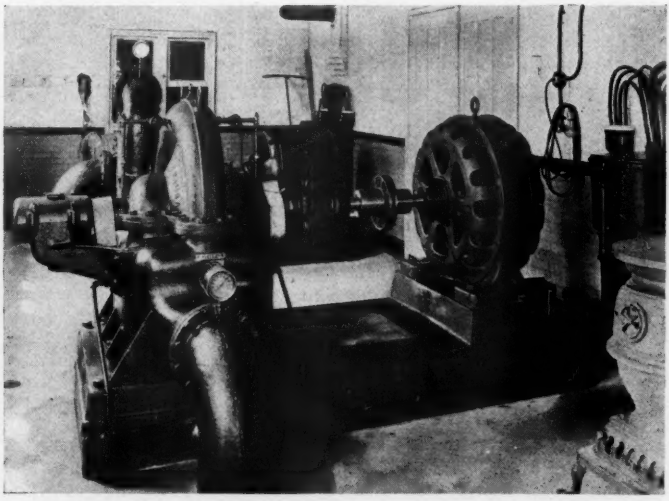


FIG. 5. HORIZONTAL SINGLE-STAGE DOUBLE-SUCTION VOLUTE CENTRIFUGAL PUMP, DIRECT CONNECTED TO AN ELECTRIC MOTOR. CONSOLIDATED WATERWORKS COMPANY, UTICA, N. Y.

This type of unit can be very satisfactorily used in small water-works plants for heads up to about 150 ft. A unit of this kind combines small floor space requirements, low first cost, with simplicity of operation and thorough reliability. The operating efficiency of units of this type is somewhat lower than that of the reciprocating pumps, but this disadvantage is frequently offset by the advantages just mentioned. A pump of this particular type can be operated with as little attention as any type of pump in small plants.

was moving 5 265 ft. per minute when it struck. Now, suppose we wish to throw this pail of water from the ground to its original position on top of the house. In order that it reach this elevation, we have to start it with an initial velocity or speed the same that it had when it struck the ground in its fall, — i. e., 5 265 ft. per minute. The formula for this law which gives the velocity of a falling body is as follows: $V^2 = 2\,gh$, in which

V = velocity of the moving body in feet per second;

g = the force or attraction of gravity = 32.2 ft. per second;
h = head in feet, or distance through which it falls.

Substituting the values used, in the above example in this formula, we find that the velocity that we have assumed, of the falling pail, was correct.

$V^2 = 2 \times 32.2 \times 120 = 7\,728.$

$V = 87.9$ ft. per second.

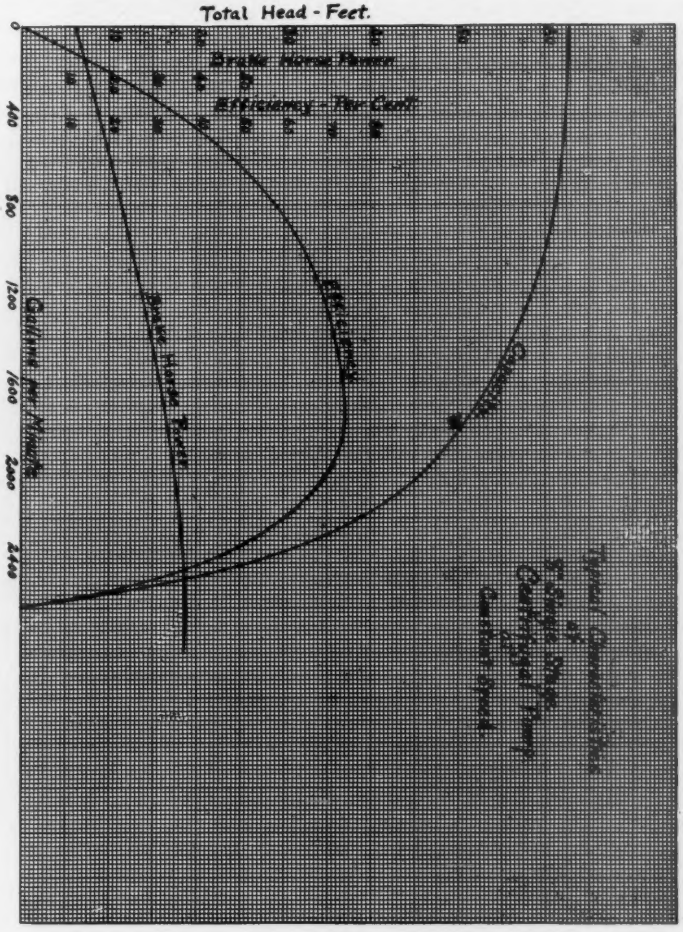


FIG. 6.

Then, as there are sixty seconds in one minute, $87.9 \times 60 = 5\,265$ ft. per minute.

It is this law or formula that is used in determining the speed of the impeller in the pump. The water, as it leaves the impeller to be thrown to

a certain height, must have the same velocity as it would if it fell from that height as just shown.

From the formula just stated it is seen that the head generated by a centrifugal pump is proportional to the square of the velocity imparted to the water at the periphery of the impeller. Generally speaking, the peripheral velocity of the impeller is equal to the velocity corresponding to the head against which the pump is to operate multiplied by a certain constant which varies according to the conditions and the ideas of the designer, but which is usually somewhat more than unity.

In other words, it can be said that the head which any centrifugal pump will generate is directly proportional to the peripheral speed of the impeller. As the peripheral speed of any impeller is a function of the speed, that is, the revolutions per minute, it is evident therefore that the head which the pump will generate must vary as the square of the speed.

In any particular centrifugal pump, supposing the impeller remains unchanged, the following characteristics will obtain:

1. The head will vary as the speed squared.
2. The quantity will vary directly as the speed.
3. The horsepower will vary as the cube of the speed.

In order to develop the theory from which these general rules are derived it would be necessary to go into an almost endless amount of figures. The three rules as stated are the fundamental rules governing the characteristics of any centrifugal pump. By referring to the characteristic curves illustrated by Fig. 6, the variation in capacity, head, horsepower, and efficiency will be clearly seen. This cut shows what are generally known as the characteristic curves of a centrifugal pump. The curve marked " capacity " shows the variation in capacity of any pump running at constant speed when operated against varying heads. The shape of this head capacity curve is generally about the same as shown.

By referring to the efficiency curve, it will be noted that the efficiency rises very rapidly from the point of no delivery, or shut-off, reaching its maximum at about the normal rated point of the pump, and falling off rather rapidly just before and at the point of maximum delivery or no head.

It may be said that the general shape of characteristic curves can be varied by variations in the design of the impeller. In other words, where it is necessary a steep characteristic curve can be produced; or, if required, a comparatively flat characteristic curve can be produced. The characteristic curve shown here is about the average for pumps working under conditions such as would be found in the average water-works plant.

The general theory which has been outlined and the characteristics as shown by the curves just referred to hold for all types of centrifugal pumps. The theory for any centrifugal pump is fundamentally unvaried. The actual shape of the characteristic curves, however, may be varied within certain limits to suit conditions. For practical reasons, however,

the head which can be generated by a single impeller is limited, and when the actual head against which a centrifugal pump must operate exceeds the practical limit of a single-stage pump, then it is necessary to use two or more stages.

It may be said that for the ordinary forms of drive, such as electric-motor drive, a single-stage pump will not ordinarily be good for more than around 200 ft. per stage. This figure is subject to variation, however, depending on conditions. For the average small water-works plant, where the pressure ranges from 100 to 150 lb., a two-stage pump is generally used.

FIG. 7. CENTRIFUGAL PUMPS DIRECT CONNECTED TO ELECTRIC MOTORS. CITY OF CHARLES CITY, IOWA.

The units illustrated in the above photograph are interesting as they show the possibilities of centrifugal pumps arranged for operation under two entirely different sets of conditions. The pumps illustrated above are each 4-in. single-suction volute pumps having a normal capacity of 500 gal. per minute each against a total net head of 135 ft. each. For domestic service the pumps are operated in parallel, each unit delivering 1 000 gal. per minute against a total net head of 135 ft. In case of fire, the units are so arranged that the two pumps on each unit will operate in series, thereby enabling each unit to deliver 500 gal. per minute against a total net head of 270 ft. Both complete units are exactly alike, one being used as a spare in case of emergency.

OPERATION OF CENTRIFUGAL PUMPS.

In order to illustrate the operation of the centrifugal pump it must be assumed that the suction pipe and pump casing are completely filled with water. When the pump is started up and reaches the proper speed, the centrifugal force generated by the impeller will throw the water contained in the impeller outward into the casing, and it will flow around the volute and out the discharge opening of the pump. This process of throwing out

the water in the impeller tends to create a vacuum in the impeller, which results in the water in the suction line rising and filling the impeller. This process goes on continuously until the pump is stopped or unless the vacuum is broken by the admission of air on the suction side of the pump.

Comparative Pumping Costs.

When the question of building a new pumping station or of making changes in the pumping equipment of an old station is under consideration, those having to do with the problem are naturally interested in determining which type of pump is best suited for their particular requirements.

No set of rules can be laid down from which interested parties could make a selection and be sure that they were making the best selection for their requirements. Such a wide variation in conditions has to be met that the formulation of any rules would be almost impossible.

The question of the proper type of pump is therefore one to be decided in each particular case after carefully considering all of the conditions which have to be met in that particular case.

Without attempting to lay down any hard-and-fast rules, certain observations with regard to this matter may be made which possibly would be of interest and of some use to those contemplating a new station or changes in their old pumping station.

In a small modern plant the choice of pumps would usually lie between a suitable reciprocating pump and a suitable centrifugal pump for the conditions to be met. In every case one fact is apparent, and that is that the first cost of a centrifugal pump for the same duty is always less than the first cost of a reciprocating pump. In fact, the first cost of a centrifugal pump is often as low as one quarter the cost of a triplex, and seldom runs over one half the cost of the triplex pump.

This general observation is of interest because of the fact that in figuring comparative pumping costs it is not the first cost alone which counts, but the yearly cost of operation, and in order to arrive at the yearly cost of operation the first cost of equipment is of interest and value because it determines to a large extent the fixed charges which have to be included as a part of the yearly cost of operation.

It is therefore well to keep in mind that in any installation the fixed charges will be less when centrifugal pumps are used, due to the lower first cost of such units.

Another general rule which should be borne in mind is that the operating efficiency of triplex, or reciprocating, pumps is in a large majority of cases higher than the efficiency of centrifugal pumps. This condition of affairs tends to balance the lower first cost with the resultant lower fixed charges on the centrifugal units.

The question of determining the proper type, therefore, is largely a question of balancing the saving in fixed charges due to the lower first cost

of centrifugal units against the saving in operating costs due to the higher efficiency of the reciprocating unit.

In the case of a new station, it may be well to remark that not only should the first costs of pumping machinery be compared for the purpose of arriving at comparative fixed charges, but the question of the first cost of the building itself is of considerable importance. Generally speaking, reciprocating pumps require more floor space, therefore larger buildings, and they require heavier foundations, all of which adds to the first cost of the building and therefore increases the investment, and consequently in stations of this type the yearly fixed charges are bound to be higher. The point to be kept in mind is that a comparison of yearly operating costs should properly include in new stations the investment both on the building and on the pumping equipment.

There frequently are cases where the increased cost of power for driving a centrifugal pump is more than offset by the decrease in fixed charges due to the lower first cost of the machine itself and further to the lower first cost of the building.

In figuring fixed charges the rate of interest and depreciation, as well as insurance, taxes, etc., are somewhat variable and must be decided according to local conditions.

From the standpoint of cost of power for operating different types of units, the accompanying chart of comparative power costs will prove of interest. This chart gives a fairly accurate idea of the cost per horsepower hour for various types of prime movers.

In addition to fixed charges resulting from investment both on buildings and machinery and the cost of power to operate the units, there is the item of labor, which must be considered in comparing the cost of operation of the different types of units.

The item of labor, while at times hard to definitely determine, is an important part of the total yearly pumping costs in most small plants. In fact, in many small plants the item of labor will frequently be found to be the largest single item of expense. In several instances which have been noted, almost the total elimination of labor charges has been made possible by using the proper type of unit. In such cases the particular unit used, if judged alone by the yearly cost of power for operating, would be considered uneconomical, but the fact that it eliminated almost entirely the labor charge made it the better unit for the conditions to be met.

The electrically-driven centrifugal pump, for example, is admirably adapted for eliminating a very considerable part of the usual attendance and labor charges. The cost of electric power for driving this type of uint, is, however, from 10 per cent to 30 per cent. higher than the cost of electric power for driving the average triplex reciprocating pump.

As a general rule, there is less danger attendant on operating a centrifugal pump without constant supervision than there is in operating a triplex pump. This is due to the nature of the design and construction of the units.

COMPARATIVE POWER COSTS.

Type of Engine.	Fuel.	Cost of Fuel.	Consumption per B.H.P. per Hour.	Cost per B.H.P. per Hour.	Cost 100 H.P. 10 Hours	Cost 100 H.P. per Year 3 000 Hours	Yearly Cost per H.P.
* Gas engine on producer gas.	No. 1 Buckwheat	$6.00 per ton	1 lb.	$0.003	$3.00	$900.00	$9.00
	Anthracite pea coal	..... 8.00 per ton	1 lb. 1¼ lb.	.004 .005	4.00 5.00	1 200.00 1 500.00	12.00 15.00
	Natural gas	.40 per M	10 cu. ft. at 1 080 Btu.	.004 .005	4.00 5.00	1 200.00 1 500.00	12.00 15.00
Diesel engine.....	Fuel oil	.07 per gal. .10 per gal.	1/15 gal.	.0047 .0067	4.70 6.67	1 410.00 2 000.00	14.10 20.00
Semi-Diesel engine	Fuel oil	.07 per gal.	1/10 gal.	.0077	7.70	2 310.00	23.00
Steam turbine condensing....	Bituminous coal	6.00 per ton	3 lb. 4 lb.	.009 .012	9.00 12.00	2 700.00 3 600.00	27.00 36.00
Compound condensing steam engine	Bituminous coal	6.00 per ton	4 lb.	.012	12.00	3 600.00	36.00
Electric power.....	.....	.03 per kw. hr. .02 per kw. hr.	....	.0225 .015	22.50 15.00	6 750.00 4 500.00	67.50 45.00
Kerosene engine.....	Kerosene	.12 per gal.	⅛ gal.	.015	15.00	4 500.00	45.00
Steam boiler coil fired.....	Fuel oil	.07 per gal. .10 per gal.	¼ gal. ¼ gal.	.0175 .025	17.50 25.00	5 250.00 7 500.00	52.50 75.00
Simple non-condensing steam engine	Bituminous coal	6.00 per ton	8 lb.	.024	24.00	7 200.00	75.00
Gasoline engine.....	Gasoline	.26 per gal.	⅛ gal.	.0325	32.50	9 750.00	97.50

*Courtesy Nelson Blower Co.

In view of the importance of the labor item in most small plants and the possibility of largely or totally eliminating this labor charge by the proper selection of a unit, it is well to carefully consider in every case the probable labor cost and the possibility of saving on this item.

Regardless of which type of unit is selected, there is always a certain amount of maintenance required in connection with every unit, and therefore the maintenance costs on various types is of interest as a part of the yearly cost of operation.

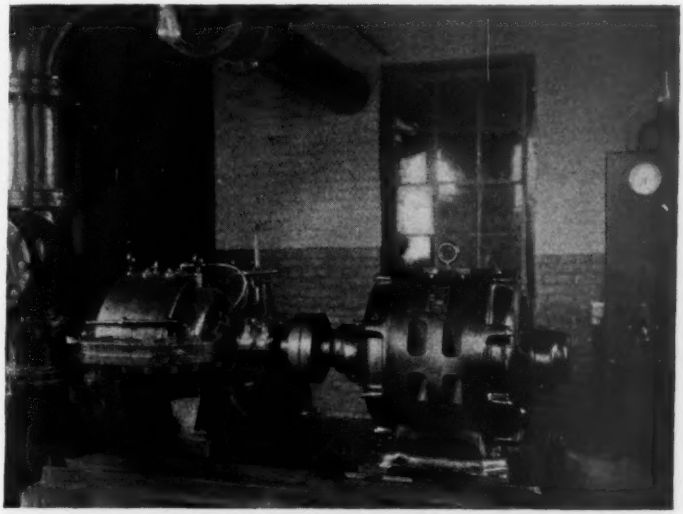


FIG. 8. MULTI-STAGE TURBINE CENTRIFUGAL PUMP DIRECT CONNECTED TO MOTOR. PUTNAM WATER WORKS, PUTNAM, CONN.

This illustrates well the modern type of multi-stage pump for direct connection to motor. Pumps of this type can be designed for pressures up to 300 lb. per sq. in. Units are simple, require small amount of floor space, are thoroughly reliable, and would show a low yearly cost of operation. They are well adapted for elimination of labor charges; as the only attendance required is a daily inspection of the unit, continued supervision is unnecessary.

The maintenance charges on modern pumps should be a comparatively small part of the total yearly cost of operation provided the pump and driving unit are not seriously overloaded and are given first-class attention. The item of maintenance, however, is often quite variable, and unless the proper machine is selected the item of maintenance sometimes becomes a serious matter. Prospective users of pumps would do well in every case to inspect the possible cost of up-keep before considering their estimate for the yearly cost of operation accurate or complete.

Summarizing briefly, therefore, the question of total yearly cost of operation, it may be said that in making up a comparison on two different types of units the following items should always be carefully considered:

1. Fixed charges.
2. Cost of power (or fuel.)
3. Labor cost.
4. Maintenance.

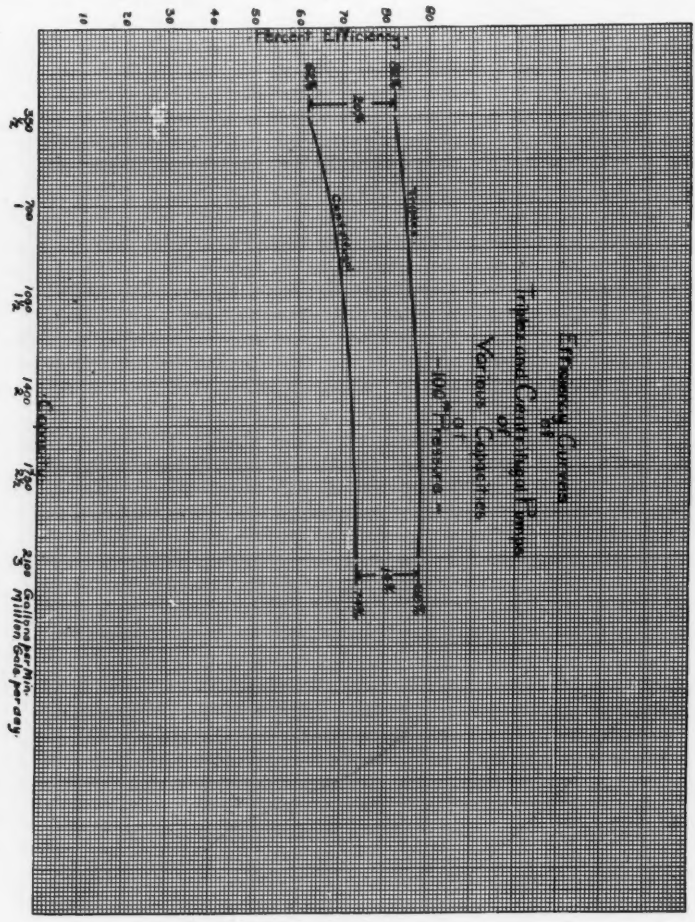


FIG. 9.

It would be impracticable here to enter into a detailed discussion of first cost of various types of pumping units. Prices for water-works pumping equipment are usually furnished on application only, and are not standard, unless perchance standard stock equipment can be used. Prices for estimating or purchasing purposes can quickly be obtained from the

various manufacturers, and fixed charges can be readily computed from them. Likewise operating efficiencies and resultant costs of power can be obtained for any particular or special conditions, from which the yearly cost of power can be readily computed.

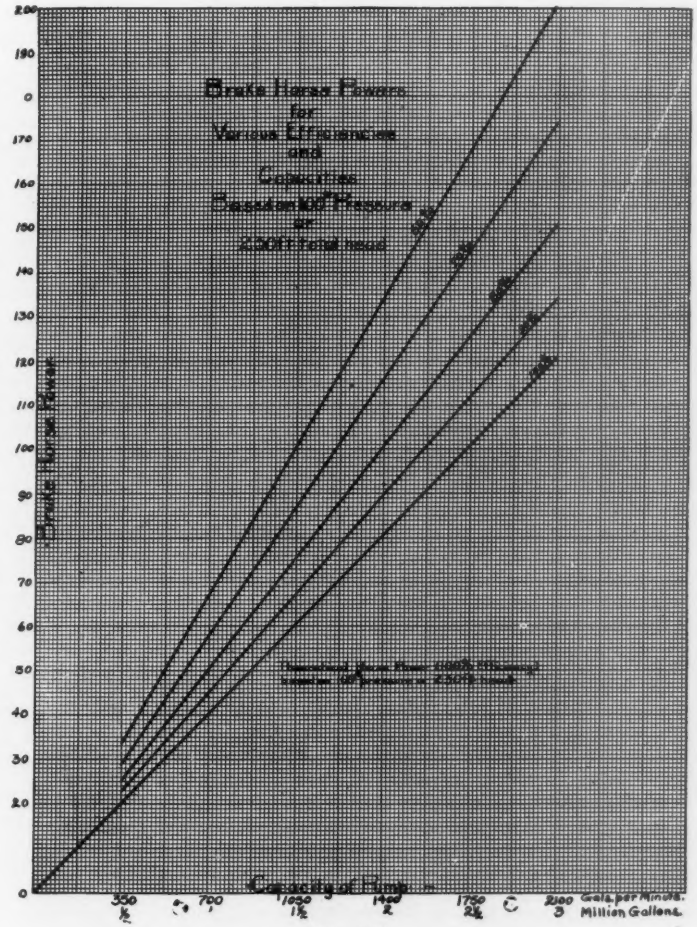


FIG. 10.

In order, however, to give some idea as to the cost of power for operating various types of units, the accompanying curves have been prepared.

Fig. 9 gives a comparison of the efficiency of modern triplex pumps as compared to the modern centrifugal pump. The horizontal scale represents capacity either in millions of gallons per twenty-four hours or in

gallons per minute. It is assumed that the average pump will operate at approximately 100 lb. pressure, and the comparative efficiencies given are based on this assumption. However, the efficiencies would not vary greatly between 100 and 125 lb. operating pressure.

By reading up from the capacity scale to the efficiency line for the proper type of pump and then reading horizontally to the left, the normal operating efficiency which may be expected for that particular capacity will be found.

For example, a centrifugal pump having a capacity of 2 000 000 gal. per day, or approximately 1 400 gal. per minute, would have an efficiency of 72 per cent. approximately; whereas a triplex pump for the same conditions would have an efficiency of approximately 87 per cent.

By using the efficiencies given, the actual horsepower required to operate each type of pump can be readily computed.

For the sake of convenience, however, Fig. 10 has been prepared. By referring to this curve sheet, reading up from the capacity just given, namely, 2 000 000 gal. per day, or 1 400 gal. per minute, to the efficiency line of the centrifugal pump, namely, 72 per cent., and then horizontally across to the B.H.P. scale at the left, it will be found that a centrifugal pump with an efficiency of 72 per cent. will require approximately 113 B.H.P. to operate against 100 lb. pressure. Similarly, a triplex pump for the same capacity with an efficiency of 88 per cent. would require approximately 92 B.H.P. to operate. The saving in power, therefore, in favor of the triplex, is 113 minus 92, or 11 B.H.P., which figure for estimating purposes might safely be used in figuring the yearly cost of power.

Having figured the proper brake horsepower, the approximate cost per horsepower hour can be ascertained by referring back to the chart covering comparative power costs, — previously shown on page 16, assuming, of course, the cost of fuel or current is known.

For example, suppose a certain triplex pump requires 100 B.H.P. to operate, as figured from the horsepower curves Fig. 10. Now, assuming a Diesel engine is to be used, with fuel oil costing 10 cents per gallon, from the comparative power costs chart we see that the yearly cost per horsepower is $20. Therefore the fuel or power cost for a year (3 000) for 100 h.p. will be 100 × $20 = $2 000. Similarly, the cost of electricity at $0.02 per hr. would be $45 per horsepower per year, or a total cost of $4 500 per year for power.

This general method of comparing the yearly costs of operation will apply to almost any plant. In certain cases it is rather difficult, however, to follow the general methods just enumerated in reaching a decision as to which type of pump should be used. This is particularly true in the case of old plants where the old pumping machinery has become obsolete or worn out, and it is simply desired to substitute new pumps for the old. In such cases the item of investment on the building is eliminated, as the building and various other parts of the old equipment usually are retained.

In such cases the question of selection depends almost entirely on the comparative first costs of the pumps only, the comparative yearly cost of power, and the possibility of saving on the labor charges.

A thorough, accurate knowledge of existing operating conditions is one of the essential requirements in selecting pumps. In fact, this is the first requirement, and should precede all efforts to compare the yearly cost of operation as just outlined. Inadequate knowledge as to the true

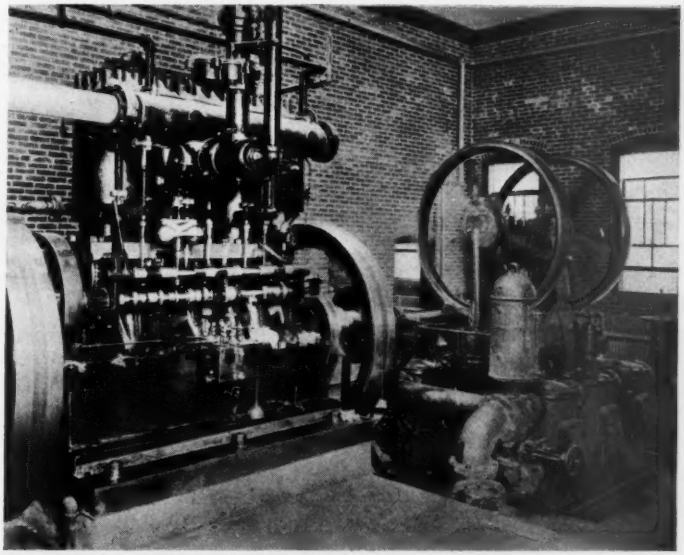


FIG. 11. TRIPLEX PUMP DIRECT CONNECTED TO PRODUCER GAS ENGINE. WATER WORKS, TOWN OF MANCHESTER, MASS.

The above illustration shows a modern gas engine driven triplex pump. The pump has a capacity of 1 000 000 gal. in twenty-four hours, against a discharge pressure of 240 ft. On continuous service this unit has shown a duty of 140 000 000 ft.-lb. for 100 lb. of coal.

A unit of this type is highly economical and thoroughly reliable. Although this particular pumping station burned down at one time, the pumps mentioned were very slightly damaged and with minor repairs were again put into operation and are running as satisfactorily as ever.

operating conditions and possible variations therein will often upset all calculations on comparative yearly cost of operation, which is the basis upon which most pumps are selected.

There is another question which often has to be kept in mind, and that is possible future developments as regards enlargements or changes in the pumping requirements. In laying out a new plant it is particularly desirable that not only the existing conditions be considered but that any reasonable changes or future developments be anticipated. By keeping in mind these facts and following in a general way the rules laid down for

figuring comparative yearly cost of operation, the proper selection of a pump should be a comparatively easy matter in every case.

Installation and Operation.

Having decided upon a proper type of pump, a word with regard to the proper installation and operation of such units may be of interest and value.

Generally speaking, careful attention should be paid to the location of any pump, particularly with regard to the suction conditions. It is very desirable that pumps always be installed as near the water as possible, that the suction lines be as short as possible and of liberal size, and that every precaution be taken to prevent leakage of air in the suction line. All pumps should be placed on adequate foundations. As far as foundations are concerned, it is not necessary to provide as large or heavy foundations for centrifugal pumps as are required for reciprocating units. In every case, however, adequate foundations should be provided to prevent settling or undue vibration on the units.

Piping should be given special attention, and all unnecessary fittings, bends, or any restrictions should be avoided.

In operating any type of unit it should be borne in mind that a pump, like any other machine, requires a reasonable amount of attention. Pumps in water-works plants usually are given fairly good attention. A small amount of attention to the packing of the glands, condition of the valves, lubrication of all working parts, and adjustment of the same, will insure satisfactory operation for a considerable period of time. Inadequate attention to these matters will, however, often cause trouble and result in very unsatisfactory operation, regardless of what type of unit has been selected.

It is hoped that this discussion will be of some value to those having to do with small water-works plants which form such a large part of the total number of water works in operation throughout the country.

The author wishes to acknowledge his appreciation of the coöperation of those mentioned below, whose contributions in the form of information, lantern slides, etc., have been of considerable help and interest:

Allis-Chalmers Co., Power Equipment Co., Nelson Blower Co., Hayes Machinery Co., Goulds Mfg. Co.

Discussion.

[*December 10, 1919.*]

Mr. A. O. Doane.* *Mr. President and Fellow Members,* — The paper of Mr. Fulton, read at the last meeting, and the paper by Mr. Symonds at a previous meeting, taken together constitute a very exhaustive study of the question of small water-works pumping engines, and leave very little ammunition for any one talking on the subject of the construction or design and construction of these small plants.

It seems to me, however, that one side of the subject, and one very important side, would be of a great deal of interest, and that is to hear from the superintendents or others, members of the Association, who have had experience in operating these plants of the various types. This is something that is given very little attention in the two papers mentioned, but is, of course, a very important subject, and one which is of the greatest interest to people that are trying to decide what type of apparatus to install, because, while the proposition presented to them by a salesman of the companies interested may appear very nice, it is quite possible that those who have attempted to operate the apparatus would know of some features, some troubles that have developed, that would be of the greatest importance to the man who has got the matter of deciding which type to select.

As was said by Mr. Fulton, and his paper brought out very clearly, the two principal types of pumps which are considered now are the reciprocating type and the centrifugal type. On the Metropolitan Water Works we have always installed the reciprocating type of apparatus, generally in rather large units, until two or three years ago it became evident that at one of the stations, called the " Arlington Pumping Station," it was necessary to install additional capacity in order to take care of the rather serious peak loads which occurred during a dry time in the summer, and also to enable us to remove, without danger of interruption of the service, a direct-acting pump which was put in some years ago with the idea of keeping this as a reserve pump until the conditions developed which would perhaps warrant putting in a larger pump of a higher-duty type. We have now in this station a million and a half gallon capacity Allis-Chalmers pump, of the cross-compound fly-wheel type. Without a very costly enlargement of the building it was impossible to put in a pump of the reciprocating type. It was desired to have a pump somewhere in the neighborhood of two millions and a half or three millions capacity, and after careful consideration of the subject it was decided to put in a centrifugal pump, largely on the basis of first cost but primarily on account of the smaller space which this unit would take up in proportion to its capacity, and to the fact that no additional foundation in the basement would have to be put in, as the unit would rest directly on the floor of the engine room, which was made of structural steel and concrete arches.

* Division Engineer of the Metropolitan Water Works.

The unit is placed in the station between two other units. On the right is the Allis-Chalmers cross-compound engine, and on the left the direct-acting Blake pump, which was one of the old type. The unit consists of a steam turbine driven centrifugal pump having two pumps arranged in series. The water for this station is taken from a main and pumped into a discharge main at a high pressure; in other words, it is a booster station. The water comes to the pump under a head of somewhere around 25 lb., and is put out at something over 150 lb. The entire head pumped against at full speed of this 3 000 000-gal. unit is in the neighborhood of 320 ft., which includes the static head and the friction.

The steam turbine was built by the Moore Steam Turbine Corporation, of Wellsville, New York. The centrifugal pumps are Allis-Chalmers. The unit was installed by The F. A. Mazzur Company, of Boston. The discharge pipe from the low pressure pump passes under the bed plate, through a channel in the small concrete foundation, and connects with the suction of the pump that discharges into the high-pressure main. The reason for this arrangement is that a slightly better duty can be obtained by using two pumps in series in this manner, and also that the balancing effect on the propellers is better, and that the unit as a whole is more accessible and considerably more convenient than a two-stage pump where the stages are enclosed in one casing.

As the speed of the turbine is 5 000 revolutions per minute and the speed of the pump is about 1 175, it is evident that a reduction gear had to be used. The gear is between the turbine and the first pump. It is of the double herring-bone type with a pinion and gear enclosed in a cast-iron case, and is lubricated by jets of oil pumped between the teeth that are about to engage. This gear was furnished by the Moore turbine people, and was cut on a very accurate gear-cutting machine in their factory.

I think a word might be said about this gear, or the subject of gears in general, because in using the centrifugal pump, unless motor driven, it is nearly always advisable or necessary to use gears, either reducing gears or gears that will increase the speed, if they are being driven by oil engines or other slow-speed engines. The gears are a very troublesome part of the proposition in many cases. A common trouble with gears is excessive noise. In some cases this is very objectionable indeed, and they emit a shrill screech that is not only disagreeable but renders it impossible to maintain any conversation in the neighborhood.

The question of gears seems to resolve itself into, in the first place, having the tooth of approved form; next, to see that the tooth is cut on a machine with the greatest possible accuracy; third, that the gear and pinion are assembled with very great care and that the material of which the gears are made is the best possible to obtain. Under these circumstances gears can be made which give very good satisfaction over a long period of time. Of course, when a gear begins to wear, the noise increases very

rapidly to such a point that generally it has to be replaced with a new one. As I stated, this pump is primarily used as a reserve pump; it is not run in regular service, so that we have not had an opportunity to see how this gear would stand up under continuous work. I have, however, had an opportunity to see and hear a set of gears precisely like this at several times during a period of about a year, during which time the gears have been run on an average of about sixteen hours a day, and, much to my surprise, these gears actually ran with less noise at the end of the year than they did the first time I heard them; so that it gives us considerable encouragement that this particular gear will stand up under a good deal of service.

The question of the turbine is, of course, another important matter. It is a good plan to have the speed as low as the conditions will warrant. As, however, the speed of the turbine is a considerable factor in economy, owing to the high velocity of the steam in the turbine nozzles, there is a decided temptation to run the speed up, especially as you can get with the highest speeds greater economy at less cost.

This particular machine has seven stages and runs at 5 000 R.P.M.

Small turbines of the single-stage type, which are quite common, are rather wasteful in the use of steam, but where the first cost is a primary consideration it is necessary in some cases to put them in. With a turbine of a reasonable size and about seven stages, they will give approximately the same economy as the steam end of a cross-compound pumping engine. The centrifugal unit is badly handicapped by the comparative inefficiency of the centrifugal pump. The contractor guaranteed the efficiency of the Arlington pumps alone at 73 per cent. We actually got a little better than that, about 75½, on our test. With the larger size pumps, however, it is quite possible to better this very much, and now they have gotten well up to 90 per cent. efficiency with a properly constructed centrifugal of considerable size, say, a fifteen- or twenty-million-gallon unit. In order to get this economy the design has to be very good, and the workmanship of the best, and also a considerable amount of bronze used, — more than in an ordinary commercial pump. The sides of the casing and the propeller should be bronze, with all surfaces finished as smooth as possible. These refinements cost considerable money, but are really worth while if you are going to have a pump which will give the best results in daily service.

This pump has a water pipe leading into the stuffing box. This is a water seal which is used to prevent leakage of air into the pump in ordinary use. It also has some effect in keeping the bearings cool. In our case, of course, the water is under pressure all the time, and we do not require them as a means of sealing the vacuum.

On the sides of the propeller there are what are called "wearing rings." These are composition rings which are fitted to the sides of the propeller, and a corresponding ring is fitted to the side of the pump casing. The object of these rings is to prevent slip or the leakage of water from

the discharge to the suction side of the pump. These wearing rings are quite important, and it is quite a study to get just the right type of ring, and also to get a clearance which will allow the pump to operate without the rings sealing or welding together through touching, and yet will not be large enough to allow an excessive amount of slipping. The advantage of having separable rings is, of course, that if the passages wear, as they will, through the high velocity of leakage through them, it is comparatively easy and cheap to replace them with other rings. We have at Clinton an electrically driven pump which is handling sewage. We make the wearing rings out of cast iron, because sewage carries considerable grit, and it is necessary to replace them about once in three months. If we had to replace the propeller and the casing in that time it would be rather a serious matter.

One drawback, to the centrifugal pump, is that you can't tell without a meter of some kind how much water you are pumping. In our case, there is a 16-in. Venturi meter in the discharge line, so that we can keep track of the pumpage. But in the small pumping station it is possible that the cost of the Venturi meter would be prohibitive.

The centrifugal pump is quite seriously handicapped now, and it looks from the coal situation as though it would continue to be increasingly handicapped in the future, by the very high cost of coal. Under such circumstances, of course, it pays to spend considerably more money and install a reciprocating type if it is going to be used in regular service. I hope that we may hear something from some of the people here that have had experience in operating these, and also in operating other types spoken of in the papers, such as the oil engines and gas-producer engines.

In investigating this subject I have visited plants operated with oil, with producer gas, gasoline, and electricity. Some features of the operation of these different plants that have come to our notice might be of interest. It is found that when operating with producer gas it is very difficult to keep the odor of the gas from escaping and from perhaps annoying neighbors, and it has always been very apparent in the stations. There has always been a strong smell of gas. Another feature which it has in common with the oil-operating engines, or any explosion type of motor, is that it is very difficult, if not impossible, to muffle the exhaust satisfactorily so as not to cause annoyance to people living in the neighborhood, and even in some cases, as the Boston Elevated found out in Medford, to people who live a very considerable distance away. I think it is sometimes impossible to muffle it so as not to cause serious annoyance, not only to people near by, but if the station sets on a ledge, or near a stratum of rock, the vibration is sometimes carried a long distance, perhaps a mile or more.

One of the latest developments, perhaps, in pumping engines, is the application of the Unaflow principle to the steam cylinders of pumping engines. This type is being experimented with by the Worthington

Pump and Machinery Corporation, and Mr. Decrow, I think, told you something about it at Albany.

MR. FRANK A. FULLER. At Wellesley we have a 1 400-gal.-per-minute pump operated by an electric motor. It is gear-connected, and we have the trouble that Mr. Doane has mentioned, — a great deal of noise, — and it is a very serious trouble, it seems to me. While we have run the pump quite a number of years, we have made out to get along with this troublesome noise, which, as he says, prevents hearing conversations, and is very troublesome.

FREDERIC PIKE STEARNS.

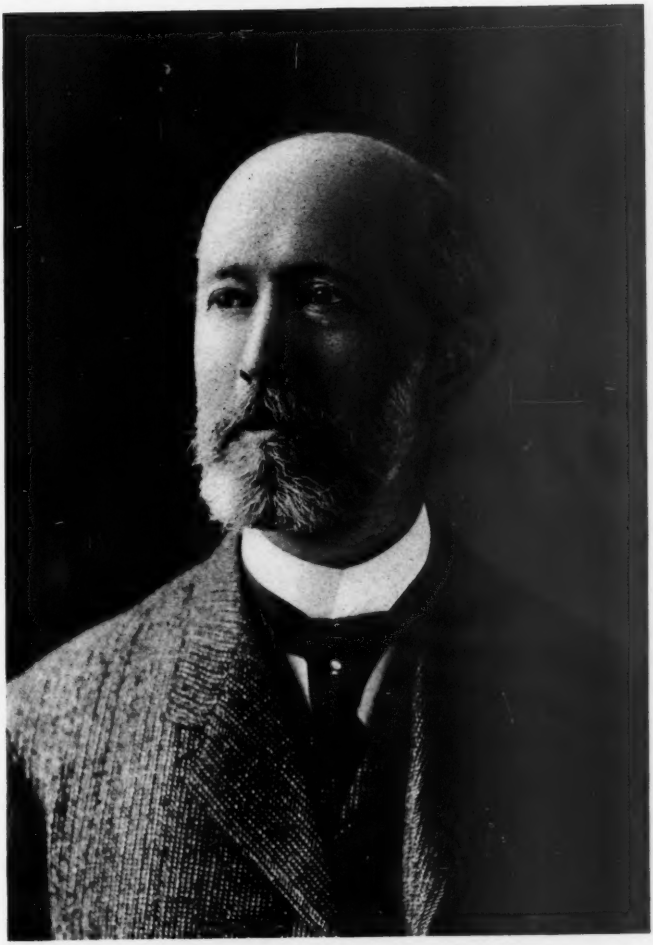
Frederic Pike Stearns, long a member of this Association, died at Boston, December 1, 1919.

Mr. Stearns was born at Calais, Me., on November 11, 1851. Like many another country boy, naturally industrious, energetic, and capable, he quickly sought the opportunities of advancement afforded by a great city, and at the age of eighteen, after graduating from the high school of his native town, he came to Boston seeking employment.

In his case no time was lost in groping for the work he was best fitted to do, as so often has happened in cases where men have afterwards made a notable record in the world. Through a casual acquaintance, it is said, he first obtained employment in the office of the city surveyor at a time when municipal engineering in this country was in its infancy and the construction of the great water-supply systems had practically only begun. Such preliminary education as he possessed would ordinarily be an insuperable handicap to the highest success in a profession like engineering, but to great natural capacity were added in Mr. Stearns's case an energy and industry that would not be denied. By devoting his spare hours to study, and by diligent application, he soon became proficient in the knowledge of those subjects required in his work, and ultimately acquired both that thorough education in technical matters pertaining to his profession for which he was distinguished and the broad general education which was so useful to him in after years.

Municipal engineering was at that time just beginning its rapid development, and in this period a remarkable group of men rose to the forefront in the profession in Boston, including J. P. Kirkwood, E. S. Cheseborough, J. B. Francis, Joseph P. Davis, Hiram F. Mills, and others, whose example was an inspiration in the development of younger men; and under the leadership of this group Mr. Stearns began his professional career.

In looking through the records of the Engineering Department of Boston, we find him soon engaged in responsible work. At the age of twenty-one he was employed as assistant engineer in the preliminary investigations for the Sudbury water supply of the city of Boston, and two years later as engineer in charge of the construction of a portion of the works. In 1880 he became connected with the construction of the main drainage works of the city of Boston, a system of sewerage so admirably adapted to the conditions it was designed to meet that with little change it has served its purpose to the present day. The most important portions of this system, the tunnel under Dorchester Bay and the outfall works at Squantum and Moon Island, were constructed under Mr. Stearns's direction as assistant engineer associated with Mr. Joseph P. Davis, who was then city engineer.



FREDERIC P. STEARNS.

Upon the completion of this work, Mr. Stearns was engaged for a short time as chief engineer in the design of the Stony Brook improvement, which was subsequently constructed in accordance with plans he devised. In a certain sense this was pioneer work in this country in the intelligent and scientific study of storm water problems.

In 1886 he was called by the State Board of Health to the position of chief engineer of that board. The State Board of Health had just been reorganized by the legislature, and, upon the recommendation of a commission of far-seeing citizens of which the late John Quincy Adams was chairman, had been charged with the oversight and care of the inland waters of the State, and given the power to advise its municipalities and citizens upon all matters pertaining to water supply, drainage, and sewerage, and the prevention of the pollution of inland waters, for the purpose of protecting the public health, promoting comfort, and improving the living conditions of its inhabitants. The remarkable body of able men charged with this responsibility, under the leadership of Dr. Henry P. Walcott, chairman of the board, and the inspiration of Mr. Hiram F. Mills, its engineer member, gathered around them the most notable group of practical scientists ever up to that time associated for public health work. The work of the board was new, no precedents existed, and the law under which the work was carried on attached no penalty in case of neglect or refusal to follow its recommendations or abide by its decisions. These decisions, in the language of those who planned this new departure in public service, were to "look for their sanction to their own intrinsic sense and soundness"; and the great influence in all matters pertaining to its work which the State Board of Health quickly acquired was due in great measure to the thoroughness and sound judgment, combined with the tact and fairness, of its chief engineer. His keen and exhaustive study of the water supplies of the State set a new standard for scientific investigations, while his tact in dealing with officials with whom he came in contact and his steadfast courage in insisting upon the right course of action secured the confidence of the public in the findings of the board and established a means of controlling and improving the water supplies in Massachusetts which has become the basis of the practice in other states.

Among his notable contributions to general knowledge made in this period were his studies of stream flow and storage, establishing the principles of the economical development of the yield of watersheds which were afterward used generally by the engineers of New England. His great interest in and knowledge of this subject led to his appointment by the New England Water Works Association, at a later time, as chairman of a committee on yield of watersheds. The report, presented in 1914, which was largely his own work, furnishes the basic facts of the yield of watersheds in New England in one of the periods of greatest deficiency that has ever occurred there, and presents an interpretation of them characterized by that clearness and simplicity notable in all his work.

His earliest important work as chief engineer of the State Board of Health was in connection with the investigations conducted by the board relative to a proposed sewerage system for the Mystic and Charles River valleys, the plans for which when presented by the board to the legislature were promptly accepted and carried out. Another notable work of this period was a plan for the creation of the Charles River basin by the construction of a dam in the neigborhood of Craigie Bridge, and it was with his aid as consulting engineer that the estuary of the Charles River has been converted from a foul and offensive channel into an attractive waterway, already a place of recreation for the great population living in its immediate neigborhood and destined to become one of the most beautiful water parks in the world. In this work Mr. Stearns became associated with Charles Eliot, of the firm of landscape architects, Olmsted, Olmsted and Eliot, who were called by the board to assist in the design. This association no doubt gave him the inspiration and indicated some of the opportunities to develop more fully one of his remarkable characteristics as an engineer, — that of making engineering structures beautiful and attractive even though designed for most utilitarian purposes.

His final and crowning achievement during his connection with the State Board of Health was a plan for a general system of water works for the supply of the city of Boston and the numerous adjacent municipalities. To the study of this problem he brought the experience acquired in his studies and investigations of the water supplies of the State and also that knowledge of the needs and requirements as well as the desires and prejudices of the people for whose health and comfort this great water supply was devised.

Upon the adoption of the plan by the legislature and the creation of the Metropolitan Water Board, Mr. Stearns resigned as chief engineer of the State Board of Health, became the chief engineer of the water board, and carried out the great work he had devised. This work was begun in 1895 and completed in 1907, at a cost of $40 000 000. The problems encountered in this great work involved the design and construction of the Wachusett dam and reservoir and its earth dike, one of the most notable structures of its kind in the world. The plan included that novel feature in public water-supply development, the utilization of the fall of the water into the aqueduct for the production of power — an innovation which has produced a very considerable revenue for the metropolitan water district. The construction of the Wachusett Reservoir illustrates one of his greatest contributions to engineering development in this country. The ordinary reservoir in New England in earlier times has often been a scar on the landscape, and even those constructed for the purpose of supplying drinking water were not uncommonly scenes of depressing desolation. The Wachusett Reservoir, named for the mountain which is the most conspicuous feature in its watershed and of the hill country of central Massachusetts, has been made one of the most beautiful lakes in New England, and even

the lines of the dams and the other appurtenances of the system have been softened to unobtrusive and even attractive features in the landscape. Spot Pond, the northern distributing reservoir of the metropolitan system, always the gem of that wonderful expanse of unspoiled wilderness known as the Middlesex Fells, has been made to retain its most attractive features, notwithstanding the fact that the changes necessary to adapt the pond to its new purpose included raising its surface ten feet above the original level.

The same is true of the other reservoirs and their appurtenances built in connection with the metropolitan water works. Pumping stations, gate houses, and other wholly utilitarian structures have not only been made architecturally attractive, but have been placed in pleasing and often beautiful surroundings.

This belief in the value and importance of attractive structures for the storage and delivery of water to be used for drinking was an outgrowth no doubt of that basic principle which underlies all of Mr. Stearns's work, — that a public water supply being, after pure air, the greatest essential to life and health, should be the best that under the circumstances could possibly be obtained, since no food or other article of diet is capable when impure of causing more serious injury. He believed that, with the limitations in our knowledge of the effect of the character and quality of drinking water upon health and life, everything should be done to secure a water of the highest natural purity, that all of the natural processes which tend toward its improvement should be availed of to the fullest practicable extent, and that every effort should be made to maintain the purity thus secured.

The metropolitan water system was his greatest achievement, and there can be no better evidence of his character, his thoroughness in the matter of all details, and the fairness of his disposition, than is found in the records of the great volume of contract work which he handled without litigation. The innumerable settlements with owners of lands and riparian rights, and with other claimants in the large enterprises that were entrusted to his care, were handled with the same unfailing good judgment and faithfulness evident in all his work.

In recognition of his contribution to the advancement of engineering, Harvard University conferred upon him in 1905 the degree of master of arts, and in 1906 he was further honored by the University of Pennsylvania with the degree of doctor of science.

His work at the completion of the metropolitan water system had given him an eminence in his profession which enabled him upon his retirement from the position of chief engineer of the Metropolitan Water Board, in 1907, to choose for his professional work in his later career as consulting engineer the problems which interested him most. These included the water supplies of Baltimore, Los Angeles, Winnipeg, Hartford, Rochester, and Worcester. He had been consulting engineer for the Board of Water Supply of New York City since 1905, and for the new water supply at

Providence since 1914. He was also consulted with regard to the construction of the Chicago drainage canal, the Mississippi power dam, and other projects in the West and in Mexico. He was one of the engineers selected by President Roosevelt to advise as to the construction of the Panama Canal, and was influential in procuring a canal with locks.

His influence was felt indirectly in a far wider field on account of its effect upon the engineers with whom he became associated. His cordial appreciation of good work, wherever it was found, and his deep interest and great assistance in the work of all engineering societies, will long be remembered, and he will be greatly missed by all with whom he ever came in contact.

Tall, erect, of excellent figure, gentle and pleasing in manner, and ever willing and patient in aiding and advising younger and less experienced members of his profession, but facing with undismayed courage and unfailing courtesy the most strenuous opposition, his was a strong character and a pleasing personality. Death claimed him before his strength declined or age had caused his powers to fail, and so we shall remember him strong and faithful, patient and kindly, with a courage that never faltered and a modesty that effaced all thought of self. It was his privilege to accomplish more for improving the lives of others than often falls to the lot of man.

X. H. GOODNOUGH,
LEONARD METCALF,
Committee.

MARCH 10, 1920.

THE PREVENTION OF THE RED-WATER PLAGUE.

BY WM. H. WALKER.*

[*November 12, 1919.*]

People who live in districts supplied with soft water — such, for example, as the New England States and New York City — are familiar with what has been termed the "red-water plague." This condition of the water is caused by the presence in it of hydrous red oxide of iron, commonly spoken of as rust. The fact that this oxide of iron is present in the water means that the iron pipes of the hot-water supply system have been correspondingly corroded by the water, and have been pitted or otherwise weakened in proportion to the amount of iron removed. Thus the iron is taken from where it is needed, namely, the walls of the pipes, — and placed in an objectionable form where it is not wanted, — namely, in the water. Many factors incident to modern city life have united in greatly increasing the daily consumption of hot water, and the loss, due to failure of pipe lines through clogging by deposited rust, as well as leaks due to pitting, has now become a most important problem.

A great deal of very valuable research has been devoted to the causes of the corrosion of iron, notably by the Massachusetts Institute of Technology; and the seed sown by the early investigators is now beginning to bear fruit. It was for many years thought that rust was formed by the direct union of the oxygen of the air, water, and the iron. Now we know that such is not the case.

The Modern Theory of Corrosion. Iron has a perfectly definite tendency to dissolve in water, with the separation of an equivalent amount of hydrogen. If there be no impurities of any kind present in the water, this solution proceeds but to a very slight extent. The surface of the iron becomes covered with a protecting layer of hydrogen, and the action ceases. If free acid exists in the water, or a substance, such as alum, be present, which upon heating liberates an acid, this hydrogen may be thrown off in the shape of a gas and the solution of the iron proceed with great rapidity. On the other hand, if an alkali such as caustic soda be added, not only is the acid neutralized and this action prevented, but the water itself is less active in its attack upon the iron.

Natural water, however pure it may be, is saturated with the oxygen of the atmosphere. While oxygen and iron do not directly unite except at a high temperature, yet the presence of oxygen dissolved in water has a controlling influence upon its ability to dissolve or corrode iron. This effect is produced by the reaction of the dissolved oxygen upon the hydro-

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gen film, with which, in the absence of oxygen or free acid, the iron protects itself. Slowly but surely this hydrogen film is destroyed and the corrosion of the iron proceeds.

When the iron dissolves in the water it exists in the difficult soluble form known as ferrous hydroxide. With this material oxygen readily unites, forming the well-known ferric hydroxide or rust. This formation of rust is a secondary reaction, and is a consequence of, not the cause of, the solution of the iron in the first place.

It is clear, therefore, that if all the dissolved oxygen be removed from water, the protecting film of hydrogen will not be destroyed, and the solution of the iron will cease. In other words, by taking out the dissolved oxygen, the cause of the continued corrosion is also removed. In any given amount of water in contact with iron the dissolved oxygen content is therefore removed in two ways, — first, the portion which unites with the hydrogen protective film, and, second, that portion which unites with the ferrous hydroxide.

Practical Consideration. It has been frequently observed that corrosion in boilers is more marked near the feed water entrance, and in hot-water supply systems it was found that over half of the free oxygen was removed by corrosion of the interior of the heater, and most of what remained was taken up by the pipes of the system before the water was drawn. It appeared from laboratory experiments that corrosion practically ceased with elimination of free oxygen, and is directly proportional to the oxygen contents of the water, other factors such as temperature and amount of make-up water being constant.

These facts led to the installation of an experimental plant for the removal of oxygen from hot water in the Irene Kaufmann Settlement House in Pittsburgh, December, 1915, where considerable trouble had been experienced with rusty water due to corrosion of iron pipes. The principle employed is to fill a storage tank with suitable prepared steel lathing (26 B. W. G.) which will pack so as to have an exposed surface of approximately 100 sq. ft. per cubic feet of space. In passing the water heated to 160° Fahr. through this metal, all the oxygen is fixed in the form of hydroxides, which are readily removed by filtration through an ordinary sand filter. The result is water inactive toward iron or other metals, free from oxygen but otherwise unaltered in composition except for the presence of a small amount of free hydrogen resulting from solution of iron in the "de-activating" tank. The results have been entirely up to expectations based on research work previously done, as the pipes carrying de-activated water have shown no perceptible corrosion in nearly four years' service, whereas before this system was installed some of the pipes were nearly destroyed in this time. The corrosion in the old piping has evidently been arrested, as no further pit holes developed after the plant had been in operation a few weeks.

Another plant was installed by us in Boston in a twenty-six dwelling

apartment house in March, 1917, to afford further study of this problem in practice under different water conditions. The design was somewhat different from the first plant described above, but the results have been equally satisfactory. Details as to the operation of these plants, which were necessarily more or less experimental, will be found in a paper on "The Preservation of Hot-Water Supply Pipe in Theory and Practice," by Speller and Knowland, Transactions of American Society of Heating and Ventilating Engineers, 1918.

The installation to be described was designed for a large twelve-story apartment building of the best type, which was constructed in 1918 on the block between Park and Madison avenues, 47th and 48th streets, New York. This was designed to de-activate 6,000 gal. of water per hour at a temperature of 160° Fahr. The size was over ten times that of any previous plant which had been operated, and presented some problems which could not be solved without experience on this scale. Some changes in the piping arrangement and filters were found necessary to put the plant in satisfactory working order, as shown in Fig. 2.

Description in Detail. The water-heating equipment is divided into two independent sections, supplying the east and west buildings. The arrangement is the same for both, therefore only the equipment for the west building is shown in detail. Fig. 1 indicates the main features of this plant in diagrammatic form. This consists of two steam heaters and storage tanks of the usual type, the outlet of which is connected with the top of a de-activating tank 15 ft. long and 5 ft. in diameter, filled through the manhole at one end with strips of steel lathing supported on cross bars 4 in. above the bottom of the tank. The water is drawn off at two places from the bottom of the de-activating tank and passed through ordinary sand filters arranged in parallel as shown. From these filters the water is passed through the system and is circulated by means of centrifugal pumps through return lines and a small booster heater to the filters and back to the system again. In this way only the makeup water is passed through the main heaters and de-activating tanks. One of the heaters has been filled with steel lathing above the heating coils. Our experience with this arrangement indicates that with storage capacity slightly greater than that usually provided in such heaters it is possible to heat and de-activate the water in one tank as shown, but it is desirable in such cases to have two tanks to provide water when either one of these tanks require cleaning. Recording thermometers are provided at the heaters and in the main from de-activator before the water enters the filters. In circulating the water through the building the temperature is reduced 25° to 30° Fahr., which is made up in the small booster heater. By this treatment, with a maximum flow of 5 000 gal. per hour, the free oxygen is reduced to less than 0.10 c.c. per liter. In the previous installations described in Pittsburgh and Boston, the average oxygen contents in periods of maximum use of water runs about 0.2 c.c. per liter without showing noticeable corrosion in nearly four

years' service. The conclusion we have reached is that this plant has been designed somewhat too large for the building, in so far as de-activating space is concerned, but affords valuable information for the proper proportions for other installations under similar conditions. In designing this installation it was the intention to do some experimental work, so the piping system around the filters was laid out in more complicated form than would otherwise have been necessary for regular practice.

While there may be other means for removing oxygen which will reduce corrosion to a minimum, such as heating the water nearly to the boiling point in a vented tank, the method described has the advantage and simplicity of being automatic in that only as much iron is taken up as is necessary to fix the free oxygen, so that several years' supply of sheets may be kept in the storage and de-activating tank. Furthermore, the water need not be heated above the temperature at which it is required for use, and no attention is needed except for the regular periodic reversal

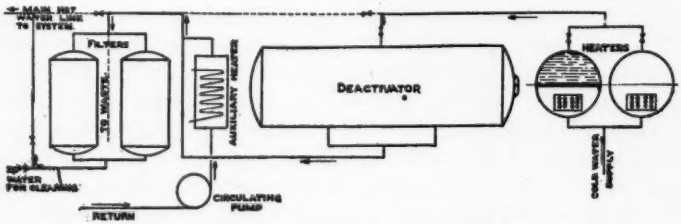


FIG. 1. GENERAL DIAGRAM OF PLANT FOR DE-ACTIVATION OF WATER, 48TH STREET AND MADISON AVENUE, NEW YORK.

of the filters, which can be readily attended to without the aid of an engineer; so that, with the exception of the interest on initial cost of installation, the cost of treatment may be said to be very little more than the cost of renewing the de-activating sheets from time to time. No allowance is required for deterioration of tanks or filters, as there is no reason to anticipate any serious corrosion of these parts during the life of the building, and for the same reason this should be true of the heaters when filled with de-activating plates.

Galvanized steel pipe was used in the installations described. Without de-activation, the life of wrought iron or steel under such conditions in large hotels, apartments, and similar buildings in New York City is about seven or eight years. Brass pipe will probably not show evidence of deterioration from this cause until a few years longer, as the water is not discolored by the products of corrosion in this case. Brass pipe is, however, often seriously weakened and ultimately destroyed by de-zincification, which is also largely prevented by de-activation of the water.

We believe that the problem of preventing corrosion in feed-water pipes and boilers can be solved in a similar manner by removal of the free

DEACTIVATING PLANT FOR ONE
OF THE LARGEST APARTMENTS
IN NEW YORK CITY
LOCATION - MADISON TO PARK AVES.
47TH TO 48 STREETS
FIG 2.
SECTION A-A
SECTION C-C
SECTION B-B

oxygen. Where makeup water is comparatively pure there is no doubt that reduction of the free oxygen to 0.10 c.c. per liter will practically eliminate this trouble.

Economizers are particularly subject to rapid corrosion where the feed water is not de-activated, and for this reason the heavy walled cast-iron tubes have been used for this purpose at a sacrifice of safety and efficiency. The use of de-activated water makes possible the use of standard charcoal iron or steel boiler tubes in economizers.

In these times economy and conservation of material mean so much to the world that we feel no apology is necessary in calling the attention of engineers to a rather neglected branch of their profession,—*anti-corrosion engineering.*

Discussion.

Mr. Robert Spurr Weston.* I do not want to let the afternoon go by without saying how much interested I have been in Professor Walker's paper. It is a very ingenious device indeed which he has brought before us for discussion. The idea of adding iron to water and letting it do its worst on that rather than on the pipes themselves is very ingenious.

With regard to what Professor Walker has said as to the degree of acidity or alkalinity which a water must have in order to get good coagulation, I should like to say that we have had a good many cases where we have had to study to find out the point of alkalinity above which there would be almost no coagulation and below which there would be sufficient coagulation. We have one of our assistants at work on a case where too much alkalinity had been added, and where it effected the solution of the suspended matter which ought to have coagulated.

There is a red-water plague of another kind which has occurred in Brookline within ten days, which you might be interested to hear about. On the 2d of November the water drawn from the taps in certain districts of Brookline began to run black; in fact, there was a quarter of an inch of black colloidal hydrate in the bottoms of tumblers of water drawn from the taps. Mr. Forbes, whom we all know, was very much exercised about it, as his telephone rang continuously, and he was forty-eight hours without having his clothes off, flushing, entreating people to have patience, looking for various causes of the trouble, etc. You will remember that about three years ago Brookline determined to purify its well-water supply, which at that time and now contains iron and manganese. The unpurified water was discharged into the mains for years, and it left a deposit —there must have been tons — of iron and manganese hydrate attached to the insides of the pipes. There was a 24-in. and a 16-in. main which ran from the Cow Bay Pumping Station about 20 000 ft., which contained a great

* Of Weston & Sampson, Consulting Engineers, Boston, Mass.

deal of this rusty matter, — iron and manganese rust. These metals had not dissolved from the pipes, but had dissolved from the soil by the very same chemical action which Professor Walker has described so clearly. Last summer Mr. Forbes made a very thorough cleaning of his force main, and got out everything that high velocity could remove from the pipe; but, as I said before, on November 2 a plague of black rust appeared at the taps. The trouble increased for a week, apparently reaching its climax about last Wednesday.

It was found that the rust on the walls of the pipe consisted of more manganese than iron. Apparently the iron which had been deposited — it is a well water which, by the way, contained about five times as much iron as manganese — had been largely removed by previous flushings, leaving a deposit containing two and a half times as much manganese as iron. This adhered to the walls of the pipe, until something occurred which caused it to slough off and brought it into the circulation.

Day before yesterday Mr. Forbes cut into the main and found that the surface of the iron pipe itself was untouched, — that is, the asphalt coating was intact, — and all the time the water coming from the deferrization plant had no manganese at all in it and was practically free from iron, was saturated with oxygen, and contained only five or six parts of carbon dioxide per million.

We were called in to ascertain the cause of the trouble, and a possible explanation is that the accumulation of gelatinous organic matter which came from the soil originally and which acted as a cement to attach this coating to the walls of the pipe, had gradually been oxidized by the action of bacteria, setting free the powdery material which dropped off the pipe, got into the water, became hydrate, and was carried on to the consumer. We have shown by bacteriological tests that there has been a gradual oxidation of this coating.

Two years ago, when the deferrization plant was started, the force main, about 20 000 ft. long, and 16 and 24 in. in diameter, discharged 3.8 million gal. in twenty-four hours. Before this last pealing off of the coating occurred they could discharge about 4 million gal. in the same time, and to-day they discharge 5 million gal. with ease.

Col. George A. Johnson.* Reduced to its lowest terms, and stripped of that mysterious verbiage which chemists are as prone to use as the medical man is to camouflage his sugar pills under a Latin name, red water is water containing iron rust. Furthermore, it is rare that water contains enough iron rust to give it a red appearance; but the water man would not be entirely satisfied unless he tagged every significant and some insignificant water defects with a sinister name. "Red water" and the "red-water plague" are examples.

You have just listened to a paper on red-water troubles prepared by an authority. Few men are better qualified to discuss this subject than Pro-

* Colonel, U.S.A., Utilities Division, Construction Division of the Army.

fessor Walker; particularly as regards the causes of so-called "red water." In some of his writings the speaker has discussed red-water troubles in an elementary way, essentially as regards alleged causes; but, as these writings will disclose, he has paid more attention to what he considers the negative phases than to those probably having a positive relation to the cause of the appearance of iron oxide in water.

Water initially containing even very small quantities of iron in solution will, upon exposure to the atmosphere, precipitate that iron as a red deposit. Certain agencies, some of which in all probability are as yet undiscovered, have a solvent action on iron and steel pipes, and thus iron rust is added to water flowing through such pipes. Rain water and even distilled water will dissolve iron.

Carbonic acid is omnipresent. It is usually present in varying amounts in all ground waters and in the majority of well waters. The ground waters of Lowell, Framingham, and Malden, Mass., contain from 7 to 25 parts per million, and the surface waters of other Massachusetts cities at times contain as high as 15 parts per million. There seems to be no fairly precise relation between the carbonic acid content of a water and the degree of "red water" it will produce. There doubtless is a relationship, but closely allied to it, in all probability, is the law of chemical combinations, to put it crudely. Again, red water will be encountered in a row of houses on a street, skipping a house now and then. The varying character of the service pipes is there responsible for the seeming phenomenon.

The opponents of rapid sand filtration or any filtration process wherein aluminum sulphate is used, direct thereat the passionate finger of blame when a red-water flurry pops up in a community where such a process of water purification is used. Within the limits of ordinary practice in the use of aluminum sulphate in water purification, the assumption that the slight increase in free carbonic acid caused by such chemical treatment is responsible for the more or less common run of red-water troubles is fanciful and cannot be substantiated. Red-water troubles are encountered in cities having pure ground-water supplies, as well as in others using the old-style slow sand filtration. The cause is not one common to all cases or localities, but is due as much, and in many instances more, to the natural character of the water supply itself, regardless of the manner in which it is purified.

And, finally, red water is objectionable for some laundry purposes and on esthetic grounds. It has no sanitary significance. Red water leaves a stain on porcelain surfaces and clouds glass containers, and may stain white or light-colored fabrics in laundering. Those are its sole points of significance. It cannot be said to be a red indicator of gross corrosion of water pipes. It is objectionable to the highly developed esthetic sense of the American citizen, however, and consequently a solution of the problem of how it may practically be overcome is desirable.

MR. FRANK W. GREEN.* The subject of this paper is one that is of greatest interest to the speaker, and it is gratifying to find that a practical method has been worked out whereby this unpleasant trouble may be overcome in a satisfactory manner on a commercial scale. The speaker wishes that he could feel that the problem is as elementary an affair as the author would lead one to believe, but in most municipal supplies there are complications which add to the difficulty of the solution.

The presence of free carbonic acid, the passage of colloidal aluminum hydrate through the sand beds of rapid type filters, and in some cases (and the speaker believes these to be of far more frequent occurrence than is generally realized) the presence of appreciable quantities of manganese is an important factor that has to be taken into consideration.

Where you have a water containing suspended matter, due either to natural turbidity or to the hydrate incident to purification by means of sulphate of alumina, there will be a coating deposited on any iron placed in the supply for the purpose of reducing the oxygen content, and therefore special means must be provided to prevent or remove such coatings, or else no action will take place. What appears to be a catalytic action has been noted in some supplies; iron placed in a small quantity of such a water kept on rusting for several months. This is important.

The speaker would like to ask Dr. Walker just what effect the presence of carbonic acid and of manganese has on the problem, and why any brass object that is connected in a water pipe will cause the corrosion of the iron pipe in its vicinity to become greater.

In regard to the use of lime at Little Falls, the speaker would like to say that lime has been used successfully at various times for the reduction of the corrosive action of the supply, but that it was found to be impossible to entirely eliminate corrosion by this means; nor was it practical to coat the inside of mains and house pipes with lime to prevent future recurrences of the trouble. The application of lime in any considerable quantity has several objectionable features, and its use is not recommended except in certain emergencies.

The author has mentioned that oxygen exists in a water supply in two forms: as a part of the water (H_2O) itself and as part of the air which is dissolved in most all natural waters. When water that is high in dissolved oxygen content is subjected to an increase of temperature or pressure, part of this oxygen becomes squeezed out and is held in suspension, — probably colloidal, — to form what may for want of a better term be called "entrained" oxygen. Upon decrease in pressure, this air appears as minute bubbles which gather together and rise to the surface to give the "milky water" which is of frequent occurrence in high-pressure systems as drawn from the tap in cold weather. This form of oxygen is more active than dissolved oxygen, and where it is present the corrosion of iron takes place about as rapidly as on surfaces which are intermittently wetted.

* Superintendent, Filtration and Pumping, Montclair Water Company.

MR. MELVILLE C. WHIPPLE.* The discussion which has been brought forth by Professor Walker's interesting paper relative to the corrosion of iron and steel water pipes suggests to me some long-time experiments along this line which were recently completed at Harvard University.

A long series of experiments was made at our laboratory in Cambridge several years ago, which showed that differences of potential exist between certain parts of iron and steel plates and pipes. These differences in potential set up galvanic currents within the material, and such currents are known to stimulate corrosion of the metal when moisture and oxygen are present. It was possible by means of a sensitive galvanometer to measure these currents.

Wrought iron of good quality exhibited currents in a slight degree, and steel covered with mill scale, as it comes from the mills, showed striking differences of potential between the metal and the scale, with consequent greater currents. If the scale was removed, almost no current could be measured between portions of the clean metal.

One of the conclusions of this series of studies was the belief that, if steel water pipes of good quality were free of mill scale when put in service, the corrosion problems so common with such material might be greatly decreased. The common methods of doing this make use of pickling acids, brushing, or sand-blasting, all of which are fairly expensive and under some conditions impractical.

The appearance upon the market of the new process "scale free" steel pipe, which has been mentioned at this meeting, made possible the use of a material free from the surface coating which was known to actively stimulate galvanic currents and thereby corrosion. In order to test this new product under service conditions, I made arrangements with Mr. F. N. Speller, of the National Tube Company, a member of this Association, to send me three samples of $1\frac{1}{2}$-in. steel pipe made of different grades of material.

The samples included scale-free pipe, National galvanized steel pipe, and copper steel pipe. A fourth sample, Byer's wrought-iron pipe, was added from the stock at Harvard University. Two pieces each of these four samples, in 4-ft. lengths, were installed April 20, 1916, in the hot-water service line in Weld Hall, a dormitory of Harvard University. Cambridge city water is used in this service.

The pipes were placed near the heater and arranged in a horizontal coil with cast-iron return bends, each of the four sections of the coil having two pipes. The following order was chosen: Galvanized, scale-free, copper steel, Byer's wrought-iron, Byer's wrought-iron, copper steel, scale-free, galvanized. Inasmuch as the balance of the service was brass pipe, the precaution was taken to insulate both ends of this coil from the brass by means of specially made hard-rubber flanges. Couplings between the

* Instructor in Sanitary Chemistry, Harvard University.

galvanized and scale-free samples were of galvanized iron, those between the copper steel and wrought iron were of wrought iron.

The coil remained in service until April, 1919, — that is, for a period of three years. At the end of that time the pipes were choked with iron deposit and had to be removed. This occurred during my absence from the country, and was carried out under the direction of Professor George C. Whipple, of the Department of Sanitary Engineering, Harvard University. The subsequent work of examination and measurement was done by Mr. Gordon M. Fair, instructor in sanitary engineering. This involved a large number of careful measurements to determine the depth to which corrosion had penetrated.

Six-inch sections were cut from each length of pipe, and these were cut in two, lengthwise, in order to lay bare the interior surface. All rust and loose scale was removed, and a survey made of each section by means of a depth gage, in order to determine the depth of pitting. A great many measurements were also made of the thickness of the pipe, both where corrosion was apparent and where it was not.

In the following table all these measurements are summarized.

THICKNESS OF PIPE AND DEPTH OF PITTING IN INCHES AT END OF THE EXPERIMENT.

Kind of Pipe.	Thickness.			Max. Depth of Pitting.	Thickness of New Pipe.
	Max.	Min.	Median.		
National scale-free.....	.149	.129	.139	.030	.156
National scale-free.....	.163	.134	.142	.060	
National copper steel.....	.175	.118	.139	.065	.156
National copper steel.....	.159	.115	.128	.070	
National galvanized.....	.152	.116	.142	.075	.154
National galvanized.....	.157	.110	.147	.080	
Byer's wrought-iron.....	.211	.124	.147	.065	.152
Byer's wrought-iron.....	.213	.111	.151	.080	

Comparison of the median measures of thickness with the thickness of new pieces indicates that all the specimens lost in average thickness. The wrought-iron and galvanized pipes lost less than did the copper steel and scale-free, due no doubt to the fibrous structure and mixture with cinder in the case of the wrought-iron, and to the protection afforded by the zinc coating in the case of the galvanized. The very high loss of the copper steel may have been the result of mill scale being loosened by the corrosion around and beneath it.

The loss in thickness, however, must not be taken as an indication of the total amount of iron dissolved or the amount of damage done. If

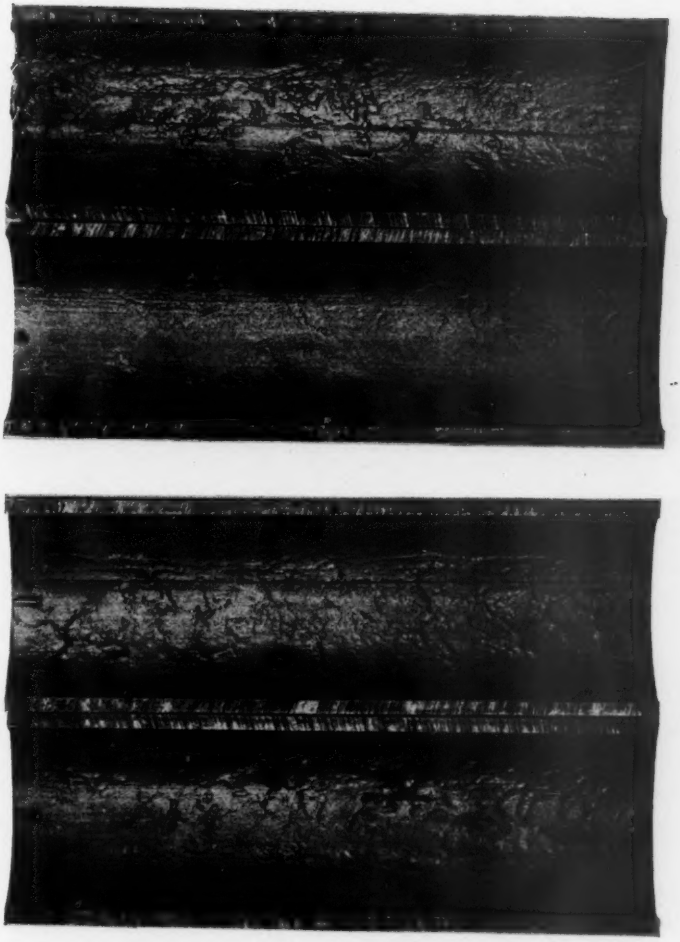
corrosion is accelerated by means of galvanic currents set up in local areas, as much, or more, iron may be dissolved than from a larger area where the rate of solution is less rapid. It is this rapid eating away of metal from small areas that ultimately results in failure by reducing the thickness of the wall to the point where internal pressure is no longer resisted. Thus local corrosion or pitting is the best measure of damage to the pipe.

In the table will be found the depths of the deepest pits encountered by the survey of the prepared specimens. The scale-free pipe exhibited in both lengths of pipe maximum depths of pitting which were lower than any of the others. Specimens of the other three varieties showed but slight differences in the maximum readings, the galvanized pipe being slightly worse in this regard.

A visual inspection of the sections used for examination was of value in determining the general extent of the deterioration suffered by the different pieces. In this connection, attention is called to the excellent photographs accompanying this discussion, which were loaned by Mr. F. N. Speller. The interior surface of each of the eight sections examined is here shown.

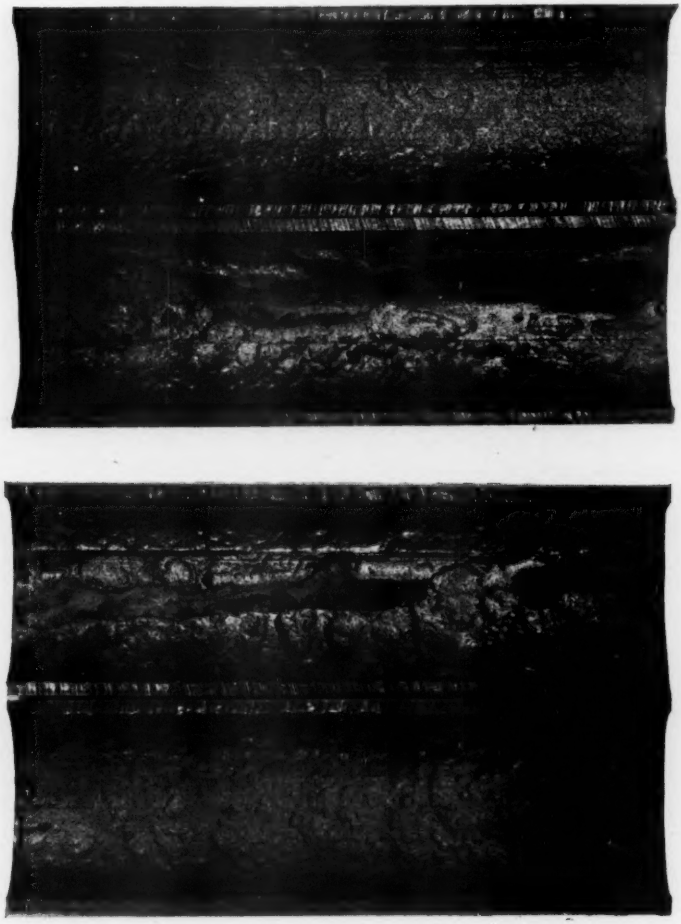
Nos. 1 and 4 represent the scale-free material. These pieces were remarkably free from evidences of local corrosion or pitting. Only a few pits were found, and these were not as large, or as deep, as those in the other samples. Much of the roughness seen in the photographs originated during the making of the pipe, and existed before the experiment was made. The uniformity of action over the surface is indicated by the even thickness viewed along the edges where the specimen was cut in two longitudinally, whereas, in the case of the other three materials, the edges vary greatly from a straight line and show the uneven thickness existing after the experiment. This is particularly the case with the specimen of galvanized pipe, which measurements showed to be more deeply pitted than any of the four materials.

Judging from the depth of pitting and the general appearance of the interior surface of the pipe, it was evident that, so far as the conditions of this particular experiment with the Cambridge hot-water service were concerned, scale-free pipe had suffered less real damage than any of the others after three years' exposure. Such corrosion as had occurred took place uniformly over the surface. There were very few pits, and these were neither large in size nor great in depth as compared with those produced in the other kinds of pipe.



1 4

TEST IN HOT-WATER SERVICE — HARVARD UNIVERSITY.
NATIONAL SCALE-FREE PIPE.



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2

TEST IN HOT-WATER SERVICE — HARVARD UNIVERSITY.
NATIONAL COPPER STEEL PIPE.

National Copper Steel Pipe.

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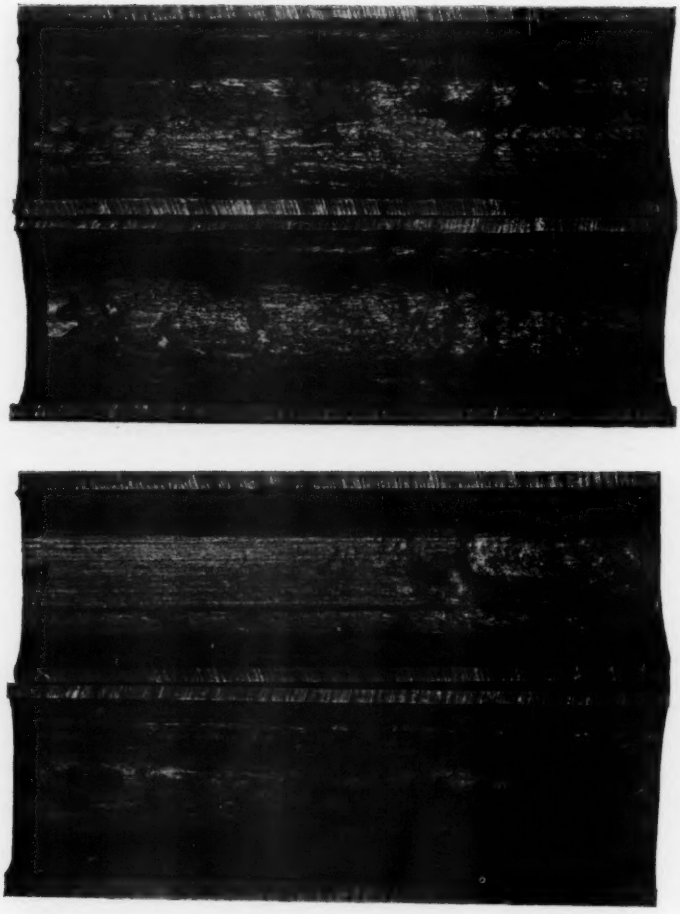
Test on Hot-Water Service — Harvard University.
National Galvanized Steel Pipe.



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TEST IN HOT-WATER SERVICE — HARVARD UNIVERSITY.
BYER'S WROUGHT-IRON PIPE.

SUPERINTENDENTS' SESSION.

OCTOBER 2, 1919.

Experience meeting, opened by David A. Heffernan, superintendent of water works, Milton, Mass.

HYDRANTS BROKEN BY AUTOMOBILES.

MR. DAVID A. HEFFERNAN. *Mr. Chairman and Members,* — I have been asked to open the discussion of this experience session, and have chosen as my subject " Damages to Hydrants by Motor Vehicles; Their Repairs and Preventives."

This seems to me to be a subject of increasing importance, growing with the popularity of motors. We have had 8 hydrants and 3 watering posts damaged by collision so far this year. This is not quite 2 per cent. of our hydrants. In every case but one, a pleasure car was responsible for the accident. I have read opinions of other superintendents who seem to think that truck drivers are the particular damage-doers. I have greater respect for the ability of the average truck driver than for the man who drives his own car, for the simple reason that under Massachusetts laws, a man who receives compensation for driving must give a creditable demonstration of his ability before an inspector of the Highway Commission ere his license is granted. Others receive an operator's license upon their sworn statement that they understand the laws applying to motor vehicles and have operated a car at least 100 miles.

None of the hydrants damaged were located in business centers, and only one close to the intersection of two streets. The causes in two cases were laid to steering gear breaking; one, excessive speed; one, truck backing did not see hydrant; one, slippery street; others, unknown.

This is a comparatively small number of hydrants damaged when these figures are studied. At a point in the east section of the town, the average number of motor vehicles passing through daily from June 1 to November 1 of last year, between the hours of 10 A.M. and 8 P.M., was 7 500 on week days and 9 800 on Sundays. Between these hours last year a total of 949 776 motors passed. Taking into consideration the fact that we suffered 9 gasless Sundays last year, it may fairly be stated that under normal conditions over a million machines go through in a year between the hours of ten in the morning and eight in the evening.

BYER'S WROUGHT-IRON PIPE.

The Massachusetts Highway Commission believes it to be the busiest thoroughfare in the state, and surpasses at times New York City's Fifth Avenue.

The cost of replacing a damaged hydrant averaged $50. This seemingly high cost has been due primarily to two causes. The hydrants without exception have been knocked over when payment of time-and-a-half or double time was necessary. The other cause is the fact that barrels cost $28.20 and stems $9.75.

We have had 14 barrels welded by the oxyacetylene process at a cost of from $12 to $15. Up to now none of these have been installed, although they have been tested under a pressure of over 100 lb. There is no question but that a saving of half the cost of a barrel will be made here.

In all but two cases, the barrel has snapped off at the flange. These two broke at the grade line.

Better policing may have been the reason that we have not been troubled along this line in the busy sections, but I believe it is because the average driver is more careful in business centers.

Several remedies for the prevention of hydrant damage have been set forth. Among them are:

1. Setting hydrant back from curb near building line.
2. Use of flush hydrants.
3. Use of bumper for protecting hydrant.

None of these appeals to me. In the first case, a hydrant set close to a building will be useless at a working fire in that building. And, further, a machine that has gathered momentum enough to jump the curb and strike a hydrant a foot from the edge has sufficient to go across the short distance of the sidewalk.

The second idea has been tried out and rejected in several of our northern cities. They are sometimes difficult to find under ice and snow. They must be salted regularly during cold weather to prevent freezing of the covers, with resulting disastrous delays. They are not as convenient for firemen as the post type.

The use of bumpers or other means of protection has, I understand, been used by some municipalities with varying success. It appears that if the bumpers are of the proper construction, heavy enough, and correctly located, they will be successful in the accomplishment of their purpose, to a limited extent. No obstruction may be placed directly in front of the hydrant without hampering the firemen in its use. They are unsightly objects for the most part.

From my own experience and that of some other superintendents, the best start is to use a strong-barreled hydrant. This will be somewhat effective. A coupé skidded on a wet road, one rainy day, in Milton, and struck a hydrant, canting it over to an

angle of 30 degrees. Of course, we supposed that the barrel had snapped off. When it was dug we were surprised to find no damage to the hydrant itself. The shock of the blow swung the hydrant around in the calked joint of the lateral. This would seem to indicate the advantage of sturdy construction in the hydrant barrel.

As regards the type of hydrant, there is more leeway. In a business where buildings are close to the street line, a hydrant that allows water to escape when the barrel is broken may result in suits for damage caused by the escaping water. In more sparsely settled sections a hydrant which permits the water to escape is an advantage, because it will more certainly be seen and reported.

We use the type with the sliding gate. This allows a certain amount of water to escape if the barrel breaks; not enough to cause any material damage, but, still, enough to be noticed. This hydrant may be equipped to prevent loss of water if desired.

The most satisfactory method of procedure, to my mind, is to use the slide-gate type of post hydrant, equipped with or without locking device, as conditions warrant, set in the tree lawn or near curb, at least 50 ft. from intersecting streets, and gate the branch, weld barrels when broken, and use no bumpers; or, if they are used, do not set them so close to the hydrant that they will hamper the use of hydrant by firemen when seconds count. There seems to be no adequate preventive. All we can do is let the accident happen, and get out of it in the cheapest way possible. What bothers me more than anything else is the collection of these repair bills. In some cases, the bill has been paid without question. In others, if the owner is not so inclined, he does not pay, and there the matter ends. The policy of the board has always been against bringing these cases to court, although in the opinion of our town counsel the owner of the machines is liable for damages.

This is only to start things. Let us hear experiences of other superintendents.

MR. S. H. MACKENZIE.* I should like to inquire what our friend uses as a locking device to hold the hydrant barrels in the thickly settled sections.

MR. HEFFERNAN. The device consists of a nut and jam-nut, placed between the top of the drip and bottom of the gate. When the hydrant is closed these nuts draw up against the bottom of the gate and prevent the gate from budging either up or down or any other way; that is, the top of the hydrant dome, packing plate, and so forth, can be taken off while the pressure is on, and the

* Engineer and Superintendent, Southington and Terryville Water Works, Southington, Conn.

gate will stay in its place. This is accomplished by absolutely locking the wedge so that the gate cannot move.

MR. MACKENZIE. What type of hydrant is that?

MR. HEFFERNAN. The Ludlow post hydrant.

PRESIDENT KILLAM. It seems to me this is a good, live subject. Most every one operating water works has more or less trouble with automobiles butting over hydrants. They tell me that if a little Ford runs into a hydrant it usually gets away, and you don't often find the machine.

MR. HEFFERNAN. I do not agree with you, Mr. Chairman, because what few hydrants we have had knocked over, in two or three cases have been by Ford machines.

If there is any gentleman here connected with water works who has had any experience with the collection of these bills, where a case has been brought to court, I should like to hear from him. We have several hundred dollars out, and we are trying to collect. We know that if we go into court it is going to cost us quite a little sum of money to fight the case, so that we are letting the matter slip.

I should like to mention one particular case which we will probably have to bring into court. There was an automobile owned by a well-known Boston man who was out driving and who told his chauffeur to leave him at a certain place, go and get his lunch, and come back for him in about fifteen minutes. Now, the chauffeur, instead of going back for his lunch, went on a joy ride, picked somebody up, and went in the opposite direction. The result was, at intersecting streets, while going at the rate, I should judge, of between 50 and 60 miles an hour, he came in collision with a car and the collision caused him to run into a hydrant and a standpipe and knock both of them over. We sent the bill for repairs to the owner of the car, and the owner of the car turned it over to the insurance people, who put up the argument that the car was stolen, that the orders given to the chauffeur were not obeyed, and that the chauffeur was responsible and not the insurance people. Now, that is a case that I think we have got to bring to court. It looks to me pretty fishy, to tell you the truth.

MR. MACKENZIE. I should like to inquire if welding pipe by acetylene gas is not successful. We had one split by frost and had it welded, but it cracked practically as fast as they welded it.

MR. HEFFERNAN. I had several hydrants during that severe cold winter that were headed by the frost, not at the top of the flange. And I have had those hydrants welded, and the job looks very good. I have only used the water pressure up to 130 or 135 lb. But as long as the welding job looks very good I am going

to install those hydrants. I am not going to pay $28 or $29 when I can have them welded for from $12 to $16. We gate all the hydrants as we put them in.

MR. FRANK J. GIFFORD.* I have had 4 or 5 hydrants welded, put under pressure, and they are all doing good work. And on a manufacturing plant in town I saw an 18-in. gate, split way around, and that was welded, put into service, and seemed to be working splendidly — no trouble at all. It may be that we have the man who is capable of doing the work, because he certainly is making a success of it.

I want to take exception to the President's remark about Ford cars, because about all my troubles have come from Ford cars — the Ford cars were not responsible, but the irresponsible drivers. We have collected about half of the bills sent out; the other half we are going to forget. It would cost us more to collect them than the bills are worth. We will let Milton collect them and get the custom established, and then we will go after them. We are a private company; Milton is not, — they have lots of money. In our case we shall forget the bills. In fact, one of the accidents was caused by a lawyer in town, and when I spoke to the clerk of our corporation, who is also a lawyer, he said, " For heaven's sake, forget it, never mind him; the abuse you will get from him will be worth more than the whole price of the hydrant." So that, after Milton gets the case on record so that it can be referred to, then perhaps we will go after them.

MR. H. T. GIDLEY.† I agree with the last speaker that we have to forget those bills. That is the way it is in our case. I know of one case where a big coal truck backed into a hydrant and broke the hydrant. I sent a bill to the coal company and they said they did not own the truck. Come to find out, it was not one of their own trucks, it was one they had hired, and the fellow that was driving the truck was buying it on the instalment plan. He showed me how much he had paid for it — which was very little. He said, oh, yes, he would settle the bill; but that is the last I ever heard from him. I guess I will have to forget that.

MR. GEORGE A. KING.‡ I should like to inquire if the insurance companies will not settle those cases where they are interested, and for that reason is it worth while to send in a bill and get perhaps a quarter of it?

MR. GIFFORD. I have had two settlements with the insurance companies.

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* Superintendent, Water Works, Dedham, Mass.
† Superintendent, Water Works, Fairhaven, Mass.
‡ Superintendent, Water Works, Taunton, Mass.

MR. W. A. MACKENZIE.* We have had at least three settlements, I think, with the Travelers of Hartford, and no questions asked. They simply paid the actual cost of replacing the hydrant.

MR. HEFFERNAN. I should like to ask the superintendents about the average cost of repairing damaged hydrants; that is, if it was done by welding.

MR. W. A. MACKENZIE. In these cases we have settled for $40 to $65. In some cases we simply took the old bottom and put a new top on, and the actual cost was the labor.

MR. GIFFORD. One peculiar case comes to my mind. I had one hydrant broken off, due to carelessness, pure and simple. The fellow that broke it got pretty fresh with the police officer and also with me. When I sent the bill in for repair to hydrant I included a bill for the estimated amount of water wasted through the hydrant, and collected the whole thing.

MR. FRANCIS H. LUCE.† I might say that wherever we have a broken hydrant we always estimate the loss of water, figure it as high as we can, estimate as high as we can, and then figure it at the retail price, and then adjust the claim. It is very seldom that in the adjustment we collect as much as the estimated water loss amounts to.

MR. DOW R. GWINN.‡ From the experiences I have heard here this morning I should say that the brand of human nature in New England is very similar to what it is out in Indiana. If I can find the man that broke the hydrant and he is worth anything, we can usually get the money; but in a good many cases the fellow has spent all the money he had for the automobile and has none left to pay for the damage.

We had the same experience in welding hydrants that Mr. Heffernan spoke about. I think it has been very successful. Instead of paying about $13 or $14 for a new stock for the barrel, we were able to have it welded for about $5 or $6. We made quite a saving. I doubt if we have collected for over 40 per cent. of our broken hydrants. One man broke a hydrant; we found out his name and sent him a bill for it. He said, "Who is going to pay me for smashing up my radiator?" — and that is all the satisfaction we got out of him.

MR. FRANK L. FULLER.§ I should like to ask the gentleman if this welding can be done in place without taking out the hydrant.

MR. GWINN. Oh, no; we have to take the hydrant out.

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* Superintendent, Water Works, and City Engineer, Wallingford, Conn.

† Superintendent, Water Works, Woodhaven, N. Y.

‡ President and Manager, Water Co., Terre Haute, Ind.

§ Civil Engineer, Boston, Mass.

MR. FULLER. I should like to say that in Wellesley we have had a good many hydrants broken in one way or another by automobiles, and have found it very difficult to collect anything.

MR. STEPHEN H. TAYLOR.* In New Bedford we have had comparatively little difficulty in collecting for our breaks. Once in a great while the fellow gets away if he is fortunate enough not to smash his car up, and we can't locate him. But I think in nine times out of ten where we locate him we get the money. The average cost of repairing the hydrants would be $40 or $50.

MR. GIFFORD. Is there anybody present who has welded hydrants which have been used since that time for fire purposes, and, if so, was there any effect on the hydrant that was noticeable?

MR. JOHN CULLEN.† We have several hydrants in my town that have been welded and have been subject to from 120 to 150 lb. pressure. We have not had any effect from any of them since; they all seem to stand the pressure.

PRESIDENT KILLAM. Have they been used for fire purposes since?

MR. CULLEN. Oh, yes; right along. In fact, they are working on the streets every day, building them and repairing hydrants, and we have a hose in use all day with pressure.

PRESIDENT KILLAM. The reason I mentioned the Ford car a few minutes ago was that our emergency truck responds to a sudden drop in the Arlington standpipe — we control the Arlington standpipe, which is directly connected with the Arlington distribution system, and this summer it has given the emergency truck very good exercise responding to calls from Arlington on account of sudden drops in the standpipe pressure. In every case it has been due to broken hydrants. During the last month three hydrants were broken, and in two out of the three cases there was not any auto there when we got there, but the police later found that they were both Ford cars. They had broken the hydrant off and gone along. If it is a larger car, the car is generally waiting for us, when we get there.

REPAIR OF INSIDE PIPE COATING.

MR. S. H. MACKENZIE. We happened to have a car load of pipe come in, the other day, from a good, reliable foundry. On looking it over after it was unloaded, the coating seemed to have evaporated from the inside of the pipe. I was wondering whether anybody here had had experience in recoating pipes. I dislike very much to lay pipe in the condition that that is in; it would

* Assistant Superintendent, Water Works, New Bedford, Mass.
† Foreman, Water Works, Woonsocket, R. I.

be better for a gas company that wants uncoated pipe than for a water supply. In my opinion, the coating is a very important matter for water pipe. We believe that we ought to have our pipe well coated, as it will increase the life of it many years. I was wondering whether there was any material that any one had used or could recommend for recoating the inside of that pipe. We have used for some time a paint on couplings on the services, which we think is quite a help. A service that we took out several years ago showed that the pipe, where it was cut 2 or 3 in. back from the coupling, was practically as good as when it was put in several years before, but the coupling was practically stopped up. Since that time we have been painting our couplings inside, and I should think it would lengthen the life of the service by several years. I was wondering whether any one had used lead lined couplings and found that was an advantage, in preventing their rusting out. Hearing the discussion on painting standpipes, I thought possibly the red lead that was used on the inside of the standpipes might be a good material to use on the inside surface of the coupling. Perhaps it would be a better material than some other kinds of paint. We have been using an elastic paint, such as we use on the universal joints. The red lead, I take it, forms a union almost with the iron on the inside of the standpipes. It does not peel off like some kinds of paint, and that is what we want on wrought-iron pipe, while on the universal joints we want a more elastic paint which will give with the contraction and expansion of the pipe. I should like to know what others have used in that line.

MR. HEFFERNAN. In answer to the question about the couplings, we use in Milton the cement-lined pipe altogether, and use a lead-lined coupling, and I think it gives a perfect connection. There is no chance for the water to come in contact with the iron at all. On the main, right inside the cellar wall, we use brass fittings on the inside, and it gives a good service right into the meter. It allows no chance for corrosion.

MR. S. H. MACKENZIE. If that works satisfactorily for the cement-lined, I do not know why it would not on the wrought-iron pipe. One peculiar thing in regard to the brass couplings is that for a short distance it will oftentimes corrode. I am unable to account for that, but I know it is so.

MR. CHARLES W. SHERMAN.* I wonder whether some of the trouble Mr. MacKenzie speaks of is not due to the corrosion on the cut end of the pipe rather than on the coupling itself. We all know that once you cut a galvanized pipe you will have a raw

* Of Metcalf & Eddy, Boston, Mass.

end, and that the rust and tuberculation will form there. With a good galvanized coupling I should not expect there would be any more rust on the inside of the coupling than on the pipe itself, but I should expect plenty of rust to form on the cut end. I do not see how a lead-lined coupling would improve that condition at all. As Mr. Heffernan says, lead-lined couplings have been used many years with success in connection with cement-lined pipe. I think they might be applied to galvanized pipe with success if something was done with the cut end, which would not be very difficult to do.

In regard to coating the inside of pipes in the field, I wish I could answer his question as to the practicability of red lead for this purpose. I do not see why it should not work very well, but I do not know of any case where it has been tried. We used to specify, and still do specify, various kinds of paint, asphalt veneer, or something of that sort, but for coating the places where the regular pipe coating is damaged in transit, or in handling, and how effective any of those things have been, I cannot answer. I wish Mr. McInnes were here, because I think he could probably tell us more than any other man I know of in the Association in regard to repainting or coating old pipes. He has had a good many old pipes in Boston which were never coated, and I think in some cases, at least, where the small pipes have been superseded those old pipes have been recleaned and relaid. But I am speaking from general inference now, and not from knowledged on that subject.

PRESIDENT KILLAM. Let me state what Mr. MacKenzie has asked. He said he had just received pipe from the foundry and certain places were not coated at all.

MR. WILLIAM R. CONARD.* This is a matter which has been troubling several of the foundries, and as yet nobody has been able to explain it. The pipe has gone through in the regular way, been coated in the regular way, no signs of overheating, and the coating as the pipe passed over the scales and through the press would be in perfect condition. That pipe would not stay in the yard over two or three days when you would find, on examination, spots anywhere from a couple of square inches in area up to 25 or 30 in., where the coating had entirely disappeared, oxidized. There is no sign to indicate where it has gone or why it has gone; it has just dissolved into the air. It leaves the surface of the pipe absolutely clean; it does not indicate that there was anything on the pipe itself to cause the coating to leave in that manner.

Incidentally, I have in mind one foundry that has been pur-

* Material Inspection Engineer, Burlington, N. J.

chasing for years the tar for their coating from one particular gas plant and has never had any difficulty, when they accidentally ran into this condition. Immediately they got tar from other parties, another concern, but still that condition persists and nobody has been able to account for it as yet.

Some years ago there was a cargo of pipe shipped by barge from one of the Delaware River foundries to New Bedford, and they ran aground in the fog, staved a hole in the bottom of the barge, and sank. They lay there in the water for probably two weeks, when it was salvaged, brought up to New Bedford; but the action of the salt water was such that the coating was in very poor condition. The insurance companies were called in to make good, and after looking around for a while they found a quantity of, not asphaltum paint but a black paint called B.P.S. Structural No. 44 which is used for painting ship bottoms. They rigged up a wooden dipping tank; the pipes were all overhauled, cleaned and cold dipped. I do not recall what the expense was; of course it was rather high, because the paint was expensive. But I saw some of that pipe still lying in the pipe yard about four or five years afterwards, and as far as appearance went the coating was in just as good condition as when it was put on, although of course the pipe had never been used. It might be interesting to some of the water-works superintendents to investigate some such method of repairing the pipe that they may take up and want to clean and use again in that way.

PRESIDENT KILLAM. If you put some more cold paint over that first spot where the paint had disappeared at the foundry, would it adhere to the pipe without any trouble?

MR. CONARD. Yes, it should, where the spots are not too numerous or bad. As they term it, they touch them up, and the new paint they put on seems to hold all right. Most of the trouble seems to be within about 4 ft. of the spigot end on the outside, and in the immediate vicinity of the bell on the inside.

PRESIDENT KILLAM. About how long is it before that takes place?

MR. CONARD. You will find it the day following the pipe going through.

PRESIDENT KILLAM. In fact, it might be shipped sometimes before it was noticed?

MR. CONARD. Yes. In a case of rail shipment, where they are hurrying it forward, it will get away from you, because the pipe might go through and be put on board the cars that day. Of course, in the one instance I spoke of, the pipe was placed in the yard and had been lying there some weeks for water shipment to Providence.

PRESIDENT KILLAM. We have been getting some of it.

MR. S. H. MACKENZIE. I do not think it is entirely the coating that has been put on. I have in mind two foundries that make specials. As a rule, the specials that have come from one of the foundries have come well coated. They have been in the yard, some of them, a long time before the high prices came into effect. Practically all of the fittings that have come from the other foundry within the last two or three years, if not longer, can be immediately told by the looks of the coating. The coating is practically all coming off from the specials that come from one foundry, while on those that come from the other it is still in very good shape.

In recoating the pipe I think we want to be pretty sure we are using the right kind of material. I have in mind an experience I had ten or twelve years ago, before I took charge of the plant. Some pipe had been taken out and relaid, and before it was relaid it was dipped, and I think when they dipped it they must have used, perhaps, plain tar without pitch or any hardening material in it, because I used to have a call about once a week to come over and flush the line out, as they were getting the odor of tar, and the water was so strong of tar that they could not use it. I think that lasted for two or three summers at least. So that, before we experiment with recoating, I think we want to be pretty sure that we are getting a material that will stick to the pipe, harden, and not cause a taste in the water.

In regard to the galvanized couplings that Mr. Sherman spoke about, a galvanized coupling is no different from a black coupling on the inside, it is only galvanized on the outside. It has no coating on the threads, and as a rule the best of the pipe does not get coated on the couplings. They leave from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch of the raw thread. If the couplings are painted when you put the pipe together, as a rule, the raw end of the pipe would be covered by that paint. But if they just paint the pipe when they put it together, it does not cover the $\frac{1}{2}$ to $\frac{3}{4}$ in. of raw thread. The way we have done is to paint the coupling on which the paint has become hardened, and paint the pipe also at the same time, and that paint would push ahead and cover the raw ends of the pipe.

MR. W. C. HAWLEY.* We have taken up quite a little pipe, burned out the joints and repainted the ends of the pipe, and that pipe has been stored in the yard for some time, some of it put in immediately. So far as I know, we have had excellent results.

MR. GEORGE A. KING. Mr. MacKenzie referred to the trouble at the sidewalk cock. I would suggest that that is possibly elec-

* Engineer and General Superintendent, Penn. Water Co., Wilkinsburg, Penn.

trolytic action. I think the paper by Mr. Weston which we had some nine years ago made some surprising statements in relation to that action due to proximity of different metals.

PRESIDENT KILLAM. In touching up pipe, the Metropolitan Water Works at Boston has always used until recently the pipe gun, which has been very successful. I have had occasion to examine considerable pipe that has been in eight to ten years, and the coating was very good. Whenever an opportunity has occurred I have been experimenting. I have some pipe now coated with paraffine inside — this is 125-degree paraffine — and some with different combinations of red lead. The red lead has been in use about five years, and I had a chance to examine it last year. It did not appear that there had been any wear or tear or any tubercles form on the red lead. While the cost, of course, is considerably more than ordinary pipe paint, I think in the end it is going to pay us on large pipe lines to adopt something of that kind, either at the foundry or in the yards, or after the pipe is laid, on account of the loss of head in pipe lines. I have in mind one 48-in. line in which the flow has decreased in fifteen years over 20 per cent. on account of the tubercles. Of course that is a pretty large figure, but the cost of relaying these lines or new lines is so great that I think it is going to pay us to consider the coating that will stand up in years to come for the interior of the pipe line.

MR. S. H. MACKENZIE. What have you found the best way to clean the pipe before applying the coating? For instance, if I wish to recoat this car load of pipe, what would be the best way to clean it to make sure the coat would stay on? Would you thoroughly clean and then clean with gasoline?

PRESIDENT KILLAM. I have never tried that method. We have used scrapers and wire brushes. That brings up another question. On the 48-in. line we recently cleaned about 500 ft. in place, using oak and chestnut scrapers, so that there would not be any hard substance next to the pipe to injure what coating there was left, and then that was thoroughly brushed out with wire brushes, then washed out as far as we could to get what dust there was left before we applied the coating. I am under the impression that you can't be too thorough in your cleaning before applying coating to any pipe. That applies to pipe also that has stood in the yard and just simply rusted. If you paint over that rust with ordinary pipe paint, in a year or two the rust will come through; whereas if the rust is thoroughly cleaned from the pipe and the coat applied, it will generally last.

MR. SHERMAN. It seems to me that your metropolitan experience of scraping and wire-brushing the inside of the pipe is

not going to help the ordinary small water-works man very much whose largest pipe is 12 in. in diameter. The problem of properly cleaning the pipe before applying the coating, when the size does not exceed, say, 16 in., is rather a serious one. It may be that a wire brush on the end of a pole, something like a chimney-sweep's brush, would give fairly satisfactory results. At the moment I can't think of anything better than that to try.

PRESIDENT KILLAM. Of course our experience does not apply to the small water-works man, but we have small pipes down to 12 in.

MR. SHERMAN. You do not clean them that way, do you?

PRESIDENT KILLAM. No, not by going inside. I went in one once, some years ago, and I came near not getting out, so that I haven't been in since. But in cleaning the 12-in. pipe in the yard, we use a long pole with a wire brush in the center, two men operating it, one on each end, and they sweep through and cover the whole pipe, and then follow that with what we call a screen brush, which takes the dust out. The painting is usually done by a long pole with a brush on the end.

MR. FULLER. I do not understand, Mr. President, just how you apply the paint. With a brush at the end of the pole?

PRESIDENT KILLAM. Yes, with a brush, the same as used in Massachusetts or eastern New England for moth work. A small brush on the end of a long pole.

MR. EDWARD D. ELDREDGE.* On the cement-lined pipe, I have used that with considerable success. I also cement-line couplings. Where wrought-iron pipe is run, I put the coupling on for good and line that at the same time, and afterwards, the next day or the second day, trim out a few threads where the next pipe will enter, and that which enters will butt up against the cement in the coupling. There is no trouble with it at all.

In the use of galvanized pipe, I have cement-lined the couplings. Reverse the coupling, take it up and cement-line it by hand, just the coupling itself, covering all the bare end threads. Then after the cement is properly set, trim out the few entering threads again. That makes a successful job. It prolongs the quality of the galvanized pipe very considerably. I consider the ideal pipe is cast-iron, cement-lined.

MR. FULLER. For service pipe?

MR. ELDREDGE. Yes.

MR. GEORGE A. BENJAMIN.† Is there anybody here who has had experience with hot water flowing back from the service pipes into the mains? I notice there are services where they have hot-

* Superintendent, Water Works, Onset, Mass.
† Manager, Water Co., Castine, Me.

water pipes, and those services rust quicker than others. That has been my experience. I have thought of obliging those people to put on check-valves in the cellar walls to prevent the hot water from flowing back.

MR. HEFFERNAN. Some years ago — I think it was a year or two years ago — that same subject was taken up at one of the meetings, regarding pressure boilers being installed in the basement close to the meter. I know in one case in Milton a boiler was installed, and the blow-off was set, I think, at 105 lb., and it stuck, and blew out their service, damaging our meter. The disk of the meter was expanded by the hot water, and so forth, so I got in touch with the plumber who installed the plumbing in the house, and we went over the subject, and put in two check-valves, one opening with the pressure and one against; that is, a check in the one flowing back — to prevent excessive pressure if the boiler got hot — so that it would go out into the street instead of going into the meter. There were two or three meters damaged, and that was the only way we could do it. But since that time we have had a rule introduced that vacuum relief valves should be put on all services, so that we do not get any trouble in those particular services. The only remedy we had was to put in a by-pass and send it back into the street mains.

MR. BENJAMIN. The reason I raised the question was on account of rusting of the fittings of the pipe. My experience with the plant I have now is that that is taken up in the service pipes. When I say that the service pipes do not rust, the plumbers come right back at me and say, " Oh, yes, they do " ; and then they will refer to some case of that kind where they have had hot-water boilers. That seems to be the difficulty that I am having now.

MR. GIDLEY. I have not run across that in services, but in a case where there were some cheap houses built to sell they put in galvanized boilers for their hot water, and did not own those houses but a very short time before they telephoned to us that our water was terrible and was spoiling all the clothes that they washed, their plumbing fixtures, and everything. I have no doubt but what the hot water caused them to rust quicker than they would have done otherwise.

STANDARD HOSE COUPLINGS.

BY F. M. GRISWOLD.*

Some of the members will remember the fact that it was thirteen or fourteen years ago when the matter of standard hose couplings was placed before this Association by a committee of which I was then the chairman. I have retained my very particular personal interest in the subject, although I have lost my official connection with it, and I feel that I ought to transmit to you now some information in relation to how the matters are progressing towards accomplishment in the standardization of hose couplings.

The first and most important element now is the fact that the National Screw Thread Commission, appointed by the Government under an Act of Congress and which is practically under the charge of the Bureau of Standards, has accepted the same standard specifications which have been adopted by this and many other associations. We have been striving for a number of years to find or devise a tool which would enable us to convert a non-standard coupling to interchange with the standard coupling, whether it is of lesser diameter than $3\frac{1}{16}$ or in excess of $3\frac{1}{16}$. We have now completed, put into operation, and demonstrated the feasibility of the tools.

Couplings which were less than 3 in. inside diameter have been enlarged by the expander and the threads, whether they be 8 or 7 or $7\frac{1}{2}$, have been re-cut to make them fit the standard. Likewise in relation to larger sizes we have been able to reduce them very readily by this new set of tools. And we have changed the conditions in quite a number of places where formerly some of the couplings were under size and in others over size. We have demonstrated the feasibility to such an extent that the state fire marshal in Indiana proposes to purchase several sets of these tools, and undertake the complete standardization of all non-standard couplings now in use within that state, under the supervision of his engineers, to each of whom will be assigned a separate district of operation.

There has been more or less criticism among the people whom we have approached on this subject. I am very glad to say that the Indianapolis water-works people have decided that when we have the tools and will come on the ground they will be glad to assist us in standardizing their couplings.

I tell you this to show how continued propaganda will bring about a desired result. I was told that if I did anything in twenty years in reference to securing standardization I would be entitled to great credit. I think that inside of three months from the time I was appointed chairman of the

* General Inspector, Home Insurance Company, New York.

Committee on Standardized Couplings I had the approval of the New England Water Works Association, which approval was supplemented by like action by some fourteen other public organizations of national importance and authority in relation to water supply and fire extinguishment, and finally of the Bureau of Standards, which has adopted exactly the standard you have and included its specifications in its last report. I have here some photographs of the tools in operation, which may be of interest to those who would like to look at them. We will probably come to you by and by and say, Here are the tools and we will show you how you can change your couplings with very little expense and with no trouble. In fact, with two men you can change twenty-five to fifty hydrants, two outlets, in a day. The expansion of the undersized couplings in place is a very simple thing, and we have had so far but a very small per cent. of them injured in the least. Several of them which did break showed a deterioration in the casting.

(*By letter.*) I assume that it will prove of interest to the organization to be informed as to the progress being made in that direction as a result of recent field work in the conversion of non-standard equipment formerly in service in the towns of Lambertville and High Bridge, N. J., and New Hope, Pa., and therefore beg to submit for your information the following statement as summarized from the report of Mr. J. H. Howland, engineer of the National Board of Fire Underwriters, who, assisted by Mr. G. W. Carpenter, representing the Greenfield Tap and Die Corporation, of Greenfield, Mass., very successfully converted the hose and hydrant equipment of the towns named, using in the work a very complete set of taps, dies, expanders, and other tools produced by the Greenfield corporation.

The report referred to is dated May 28, 1919, and may be briefed as below:

"During the past two weeks and pursuant to the receipt of official authorizations, the writer, with the valued assistance and coöperation of Mr. G. W. Carpenter of the Greenfield Tap and Die Corporation, converted to the National Standard the threads on all hose couplings, hydrant nipples and caps and play pipes, special fittings and connections to fire apparatus or equipment, in the municipalities and protected manufacturing concerns of High Bridge and Lambertville, N. J., and New Hope, Pa."

High Bridge, N. J. (May 12 to 20 inclusive):

"The original threads having an outside diameter of 3 in. and a pitch of 8 threads to the inch, were made to conform with the National Standard. The fittings so converted were as follows:

"(1) At the two borough fire stations — 30 pairs of hose couplings, 7 play pipes, 4 hydrant hose gates, and 2 chemical connections.

"(2) At the Taylor-Wharton Iron and Steel Plant — 53 pairs of hose couplings, 14 hydrant hose gates, 11 play pipes, 10 hydrant caps, and 16 hydrant nipples.

"(3) A total of 103 nipples and a like number of caps on all of the borough hydrants."

Lambertville and New Hope:

"The threads in these municipalities and the local manufacturing plants having originally an outside diameter of $3\frac{1}{16}$ in. and a pitch of 8 threads to the inch, it was only necessary to re-chase the threads with the standard tap and die to change the pitch. This work was accomplished easily, and except for slight delays in finding the thread of male fittings (having pitch diameter slightly greater than Standard) with the standard die, without any delays."

The threaded fittings which were made Standard included:

"(4) At the three Lambertville fire stations a total of 56 pairs of hose couplings, 7 play pipes, 7 chemical or pump connections, 2 siameses or Y's, 5 double males or male and female specials, and 2 suction reducers.

"(5) A total of 80 hydrant nipples on 40 Lambertville street hydrants. The caps on these hydrants were not altered, as they made an excellent fit with the re-chased threads on the nipples.

"(6) At the plant of the N. J. Rubber Company, 14 pairs of hose couplings, 8 hydrant nipples, 2 fire pump connections, and 5 play pipes.

"(7) In the New Hope fire station, 19 pairs of hose couplings, 5 play pipes, and 2 steamer connections.

"(8) At the plant of the Universal Paper Bag Company, 6 hydrant nipples, 8 pairs of hose couplings, and 2 play pipes.

"(9) At the Union Paper Mill Manufacturing Company, 6 hydrant outlets, 11 pairs of hose couplings, 4 play pipes, and 5 fire pump connections.

"The above work of standardization was done in $2\frac{1}{2}$ days by 3 men, with one additional helper to handle hose a portion of the time. From the results obtained it is estimated that 2 experienced men can standardize threads, having an outside diameter of $3\frac{1}{16}$ in. and either 7 or 8 threads to the inch, on 125 pairs of hose couplings, or on 75 two-outlet street hydrants in a day."

During the operations above indicated there was a surprisingly small number of instances in which hydrant nipples and male end couplings were fractured during the process of expanding such as were of undersize, such fractures being entirely due to thinness of the shells or to inferior grade of metal composing the castings. Taking the work of conversion as a whole, the results are particularly gratifying from a mechanical viewpoint, and appear to warrant the acceptance of the conclusions reached by Mr. Howland that—

"It is believed that with the suggested alterations and improvements made in the complete kit of tools, the work of standardization in the field will prove thoroughly practicable and in every way satisfactory.

"From the results obtained in this first field work it is believed that we have sufficient data to overcome any difficulties likely to be met with in the work of standardizing undersized fittings down to an outside diameter of $2\frac{3}{3}\frac{1}{2}$ in. It would perhaps be advisable before undertaking to standardize fittings in a large number of municipalities, to obtain an authorization and standardize some city or town having oversized fittings with outside diameters of $3\frac{5}{6}\frac{5}{4}$ or $3\frac{3}{3}\frac{3}{2}$ in."

In presenting to you this statement of progress I feel assured that we

are all warranted in feeling justified in our purpose to bring about this much needed condition of harmonizing our private and public fire-fighting utilities to a uniform specification, and gratefully give appreciative recognition to the consistent and continued support given by the N. E. W. W. Association in forwarding this worthy endeavor to assured accomplishment.

Quoting from Mr. Howland, "You will note that we are rapidly approaching a stage of development where our long-enduring though cherished movement is about to 'go over the top,'" and I trust that the accomplishment of purpose as above indicated may prove as much of an inspiration to further effort by your Association as it certainly does to the writer.

MR. CHASE. Do the nipples have to be taken out of the hydrants to do the work?

MR. GRISWOLD. No; it is not necessary to remove them.

PROCEEDINGS.

December Meeting.

Hotel Brunswick,
Boston, Mass., December 10, 1919.

The President, Mr. Samuel E. Killam, in the chair.

Elected for active membership, William A. Nial, construction engineer, Troy, N. Y.

Col. Richard K. Hale gave an interesting account of his experiences as an officer of the A. E. F. during the World War.

The report of Committee on Budget for 1920 was read by Mr. George A. Carpenter, chairman. (Printed in December Journal.)

Discussion of Mr. Creed W. Fulton's paper, "Modern Pumps for Small Water Works," by Mr. A. O. Doane and Mr. Frank L. Fuller.

Mr. Frank J. Gifford, superintendent Dedham Water Company, Dedham, Mass., read a paper entitled "Description of Motor-Driven Portable Thawing Machine Mounted on Truck." Messrs. J. M. Diven, Reeves J. Newsom, Frank L. Fuller, Morrison Merrill, Wm. N. Bonner, J. A. Hoy, David A. Heffernan, George McKay, Jr., and H. V. Macksey took part in the discussion.

The President then introduced Mr. C. J. G. Haas of the H. Mueller Manufacturing Company, who urged upon the Association the advisability of appointing a committee of the Association to confer with a committee of the Brass Manufacturers Association, with a view to standardizing brass goods.

On motion of Mr. J. M. Diven, seconded by Mr. Frank L. Fuller, it was voted to appoint a committee of three to act in conjunction with a committee of the American Water Works Association with the National Association of Brass Manufacturers, in the consideration of this matter.

Adjourned.

Annual Meeting.

Hotel Brunswick, Boston, Mass.,
January 14, 1920.

The President, Mr. Samuel E. Killam, in the chair.

The following, properly endorsed and recommended by the Executive Committee, were duly elected active members: Robert Gardner, Lowell, Mass., superintendent Lowell Water Works; Arthur H. Pratt, Newark, N. J., designing engineer North Jersey District Water Supply Company;

Chen Tan, Tientsin, China, assistant field engineer, Grand Canal Improvement Work, China, — three.

In connection with the history of the 26th Engineers which is soon to be published as a number of the New England Water Works JOURNAL, the President introduced Lieut.-Col. F. Scheidenhelm, who told of the activities of the 26th Engineers in France in providing water supply for the troops.

Mr. John M. Goodell, editor of the American Water Works Association *Journal*, gave a short talk.

MR. CHARLES W. SHERMAN. Mr. President, the last few meetings, those of us who have been coming to these meetings for a number of years have, with much regret, missed a face that has been familiar to us at a great majority of the meetings ever since this Association was formed. That is the face of Mr. Robert C. P. Coggeshall, although I probably did not need to mention the name to the older members. Mr. Coggeshall's health is not what it was, and it is difficult for him to get to our meetings. I know that he wishes he could come, but I doubt if he wishes it any more than most of us wish he could be with us. I want at this time to offer a resolution of recognition and appreciation to be sent to Mr. Coggeshall:

"The New England Water Works Association, in annual meeting assembled, records its grateful appreciation of the valuable services rendered to it by Robert C. P. Coggeshall throughout the life of the Association, and sends him its cordial greetings and best wishes for 1920."

(The motion was duly seconded and unanimously carried by a rising vote.)

THE PRESIDENT. We have recently lost by death one of our active honorary members. I refer to Frederic P. Stearns, who has been the father of our water supply of this district, and the father of a number of other engineering projects. A committee has been appointed and will report later on the death of Mr. Stearns.

REPORTS OF COMMITTEES.

Collection and Standardization of Rainfall and Run-Off Measurements.

Mr. William T. Barnes, representing the committee, reported that no progress had been made since the convention at Albany.

It was decided at the joint meeting with the committee of the Boston Society of Engineers, that the Boston society should confine its work largely to rainfall and run-off statistics bearing upon water power, leaving to the committee of this Association the collection of data bearing upon water works.

Mr. Barnes emphasized the importance of the members sending in

all available data, and stated that it was the purpose to have this data collected once in three or four years, and suggests that the Association, through committees, have it brought up to date from time to time. He further stated that Mr. Goodnough, who brought the data down to 1912, had kindly brought this up to near the present date, and that it will soon be ready for publication.

Revision of Constitution and By-Laws.

Mr. Henry V. Macksey said that progress has been made, but that no definite report is ready at this time.

Standard Specifications for Cast-Iron Pipe and Special Castings.

Mr. Frank A. McInnes stated that it had been impracticable to make much progress during the war upon this subject, and that the cast-iron pipe business was still in such shape that it had not been practicable to go into the matter.

Definite results are hoped for during the coming winter.

Standard Specifications for Fire Hydrants.

Mr. H. Q. Lacount by letter stated that the manufacturers had promised to give the information desired, but as yet data had not been received.

The committee appreciates the importance of finishing this work without further delay, and expects to be able to submit final report within the next few months.

Report of Committee on Statistics of Water-Purification Plants.

DECEMBER 20, 1919.

TO THE PRESIDENT AND MEMBERS OF THE
NEW ENGLAND WATER WORKS ASSOCIATION:

INTRODUCTION.

Gentlemen, — The preliminary report of the Committee on Standard Statistics for water-purification plants was read on September 9, 1914, and published in the JOURNAL, Volume XXVIII, No. 3, pp. 230–237. The presentation of this report was followed by several meetings of the committee, and subsequently by the presentation of the final report on January 13, 1915.

On January 13, 1915, you continued the committee, at its request, to observe the trial of these statistical forms in practice. The blank statistical forms which the committee submitted with its final report were sent to a large number of plants represented in the Association, and many of these responded by using them to present their statistics. The committee has several sets of these records on file.

The World War interfered with the work of the committee, and hitherto it has been unable to present the results of the trial of the forms in practice and its final recommendations, although it has presented verbal reports of progress at the annual meetings of 1916, 1917, and 1918. The criticisms of those who have used the forms, and further study of the problem by your committee, have resulted in some changes and improvements which will make the forms usable by a larger number of plants. Exclusive of typographical corrections, the changes are as follows:

Table 1.

Add the words "before Treatment" to title. Omit the "Permanent Hardness" column, and substitute a blank column to be used for hardness, manganese, lead, copper, sulphate, or other determined constituents. Change the next to the last column to read "Total Microscopic Organisms per c.c.," and change its note to read, "Mention important genera; does not include amorphous matter."

Table 2.

Add footnote, "For certain waters the above ranges should be subdivided to read:

0—5; 6—10; 11—15; etc."

Table 3.

For certain waters the above ranges should be subdivided to read:

0—25; 26—50; 51—75; 76—100; etc.

Substitute dotted line for "Gelatine," because the use of some other medium is necessary at certain plants.

Table 4.

Omit the "Permanent Hardness" column, and substitute blank column as in Table 1. For "Iron," substitute "Total Iron."

Table 6.

Add footnote, "For some waters the above ranges should be subdivided as follows:

0—5; 6—10; 11—15; etc."

Table 7.

Omit abbreviations from tables, such as "No.," "+," "—," etc., so that headings may read "Number of Positive Results," "Per Cent. of Positive Results," "Per Cent. of Time," etc.

*Table 9.**

Add "Feet" to the "Average Loss of Head" column.

*Table 10.**

For "Total Sand Scraped," substitute "Total Sand Removed by Scraping," and make subcolumn read "Depth in Inches." Make next column read "Number of Filters to Which Sand was Restored" instead of "is Restored."

Under certain columns indicated on the table, add the following footnote:

"In larger plants the maximum and minimum results should be given in addition to the average."

*Table 12.**

Change arrangement and form to read as follows:

* This table given in original report and published in advance copies of same, but not in JOURNAL.

TABLE 12.

WATER PURIFICATION WORKS IN CITY OR TOWN OF.....

Annual Cost of Operation and Fixed Charges per Million Gallons of Water Delivered to Mains for the Year 19 .

COST OF OPERATION AND MAINTENANCE.	Year.	Previous Years.	
	19	19	19
A. *Operation.*			
Pumping*			
Chemicals and Treatment {			
.....			
.....			
Supervision			
Laboratory { Salaries			
Laboratory { Supplies			
Attendance			
Watchmen			
Cleaning Basins			
Sand Raking			
Sand Scraping			
Sand Washing			
Sand Restoring			
Total Sand Cost			
Wash Water†			
Heating			
Lighting			
Telephone			
Stable and Garage			
Miscellaneous			
Total Cost of Operation per Annum			
Ditto, per million gallons			
B. *Maintenance.*			
New Sand			
Buildings and Grounds			
Repairs			
Miscellaneous			
Total Cost of Maintenance per Annum			
Ditto, per Million Gallons			
Total Cost of Operation and Maintenance per Annum			
Total Cost of Operation and Maintenance per Million Gallons			
Total Fixed Charges per Annum			
Total Fixed Charges per Million Gallons			
Total Cost of Purified Water per Annum			
Total Cost of Purified Water per Million Gallons			

* Pumping raw water, or additional cost of pumping water because of purification.
† Including cost of pumping wash water.

All Tables.

Add blank space for name of City, Town, or Company.

Omit abbreviations as far as practicable, particularly "No." and "+." Correct punctuation, and in footings substitute a dotted line for right lines in spaces not to be used. Also make the line between each table and its footing a double one.

Examples.

Examples showing the use of each table are appended to this report.

Other Tables.

Your committee's report covers statistical forms for monthly and yearly results only. Most plants should also provide themselves with a monthly record sheet to be used to collect the data for determining the average monthly results. Because of the great variation in plants, it is impracticable for a committee to devise a form which could be used by all. Therefore the management of each plant is urged to prepare its own form. The form used at Little Falls, N. J., is given as an example.

ENGINEERING SUMMARY OF DAILY RESULTS

THE MONTCLAIR WATER CO. FILTRATION WORKS

SUPT. ..... LITTLE FALLS, N.J.

Day of Month	Plant in Operation (Hours)	Number of Service Hours	Length of Runs (Hours)	Filtered Water (Million Gallons)				Average Loss of Head		Washing Records			Chemicals Applied									
				Delivered to Mains	Wash. Water	Per Acre per Day		Initial	Final	Number of Washes	Average Minutes	Per Cent Wash Water	Sulphate of Alumina			Chlorine			Lime			Soda		
						Yield	Rate				Air		Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million
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Total																								
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ANALYTICAL SUMMARY OF DAILY RESULTS

THE MONTCLAIR WATER CO. FILTRATION WORKS

SUPT. ..... LITTLE FALLS, N.J.

Day of Month	Chemical Results (Parts per Million)												Bacteria per Cu. Cm.								B. Coli			Micro Organisms Standard Units Per C.C. River
	Alkalinity		Free Carbonic Acid		Dissolved Oxygen		Turbidities			Color			Agar	Gelatine ● 20°C.							Nº Positive			
							River (5)		Del. (3)	River (3)		Del. (3)	37°C.	River (3)			Del. (3)			River (1)	Del. (3)		
	R (3)	D (3)	R (1)	D (1)	R (1)	D (1)							R (1)	D (1)			R	D			0.1cc (2)	1cc (1)	10cc (2)	
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CHEMICAL ANALYSIS ON..... {River Water (Cl. ....) (T. Hard. ....) (Incrust. ....) (Iron ....) (Oxy. Cons. ....)
{Delivered ● (● ....) (● ....) (● ....) (● ....) (● ....)

In a large plant it is often desirable to summarize certain results which would be significant to the average citizen, for presentation in the annual report of the operation of the plant. Here, again, it is impracticable to devise a form which would fit all plants. Therefore the following list of significant data is given as a guide:

SUMMARY OF PRINCIPAL DATA.

(Mechanical Filter Plant.)

Gallons Filtered	Total per Annum Average Daily Maximum per Day Minimum per Day
Rate of Filtration (Million Gallons per Acre per Day)	Average Maximum Minimum
Average Turbidity of Water	Unfiltered Water Filtered Water
Average Color of Water	Unfiltered Water Filtered Water
Average Alkalinity of Water	Unfiltered Water Filtered Water
Rate of Application of Chemicals. (Give Kinds.)	Average Maximum
Average Percentage of Wash Water	
Average, Maximum and Minimum Numbers of Bacteria per c.c.	Unfiltered Water Filtered Water
B. coli Index	Unfiltered Water Filtered Water
Total Iron	Unfiltered Water Filtered Water
Total Cost of Operation and Maintenance per Million Gallons	
Total Cost of Water per Million Gallons	

Recommendations.

Your committee feels that the forms as revised are suitable for adoption by the Association and for general use in water-works plants. We therefore recommend that they be printed and sold singly or in sets at a price sufficient to cover their cost. We also recommend that each set should include a copy of the 1915 report of the committee, revised to agree with subsequent reports of the committee. The committee also asks that it be discharged as soon as the first printing of the forms and of the revised report has been made.

Respectfully submitted,

GEORGE C. WHIPPLE, *Chairman.*
FRANCIS D. WEST.
ELBERT E. LOCHRIDGE.
FRANK W. GREEN.
ROBERT SPURR WESTON, *Secretary.*

Note. — Forms used by various water works, submitted with this report, are on file at office of New England Water Works Association.

Leakage of Pipe Joints.

President Killam stated that no progress report was available, due to Mr. Barbour's illness.

Standard Specifications for Water Meters.

Mr. Charles W. Sherman made progress report, of which the most important item was the appointment of a committee by the American Water Works Association to consider this subject, and to act jointly with the committee of this Association.

Proposed Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions.

Mr. Frank A. McInnes reports no definite action since the annual meeting. He reminds the Association, however, that it is very important that the members furnish information relative to this subject to the committee.

Mr. McInnes said that the committee had published in its report a list of some thirty cities which had been graded under the schedule, and has asked for comments and criticisms. The committee wished to repeat this request.

A National Water Law.

MR. CALEB M. SAVILLE. This committee has communicated with the Water Service Committee of the Engineering Council, and is waiting for report from them, which will be turned over to the Association later.

Extension of Mains.

MR. CALEB M. SAVILLE. No report is ready at this time.

National Department of Public Works.

Mr. Henry V. Macksey states that there is really nothing further to report beyond that already sent in, recommending that the individual members give the Department of Public Works such support as they could, and that the Association, as a body, should not formally support the movement, because it was unable to give the financial backing which might be necessary.

President Killam stated that a meeting was held yesterday and to-day in Washington on this subject, Mr. Metcalf representing this Association, who will undoubtedly make a report at the next meeting of the Association. He further stated that Professor Swain had been invited to talk on the National Department at the February meeting.

Mr. Charles W. Sherman moved that Committee on Public Works be discharged, which was duly carried.

Reports of the other committees were accepted as reports of progress, and committees continued.

Report of the Secretary.

January 2, 1920.

Mr. President and Gentlemen of the New England Water Works Association, — The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 899, constituted as follows: 12 Honorary, 810 Active, and 77 Associate Members, there being a net loss for the year of 6. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1919.	Honorary Members		13		
	Died		1		
			—		12
January 1, 1919.	Total Members			815	
	Withdrawals:				
	Resigned		33		
	Dropped		18		
	Died		8		
			—	59	
				—	756
	Initiations:				
	February		4		
	March		6		
	June		9		
	September — October		19		
	November		9		
	December		1		
			—		48
	Reinstated:				
	Member dropped in 1917		1		
	Members dropped in 1918		3		
			—	4	
	Elected in 1918, qualified 1919,			2	
				—	6
					— 810
January 1, 1919.	Total Associates			77	
	Withdrawals:				
	Resigned		4		
	Dropped		2		
			—	6	
				—	71
	Initiations:				
	January		1		
	September		2		
			—	3	
	Reinstated:				
	Associates resigned in 1919			3	
				—	6
					— 77
January 1, 1920.	Total membership				899
January 1, 1919.	Total membership				905
	Net loss				6

Receipts for 1919.

Initiation fees			$234.00
Annual dues:			
Members	$3 231.14		
Associates	1 440.00		
		$4 671.14	
Fractional dues:			
Members	$35.00		
Associates	40.00		
		75.00	
Past dues		35.00	
Total dues			4 781.14
Advertising			1 903.75
Subscriptions			261.00
JOURNALS			129.00
Sundries			835.16
Total receipts			$8 144.05
There is due the Association:			
Advertisements		$60.00	
JOURNALS		2.00	
Meter rate sheets		1.00	
Total		$63.00	

Respectfully submitted,

WILLARD KENT, *Secretary.*

REPORT OF THE TREASURER.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest			$186.40
Initiation fees		$234.00	
Dues		4 781.14	
Total received from members			5 015.14
JOURNAL:			
Advertisements		$1 903.75	
Subscriptions		261.00	
JOURNALS		129.00	
Sale of reprints		39.20	
Total received from JOURNAL			2 332.95

Miscellaneous Receipts:		
Sale of "Pipe Specifications"	$18.90	
Dinners	658.50	
Certificates of membership	12.00	
Buttons	.75	
Meter rate sheets	2.68	
June excursion	46.84	
Albany pictures	48.00	
Index	1.00	
Total miscellaneous receipts		788.67
Total receipts		$8 323.16

Expenditures.

JOURNAL:		
Advertising agent's commission	$122.50	
Printing	1 820.00	
Editor's salary	300.00	
Editor's expense	23.71	
Reporting	347.41	
Reprints	169.50	
Envelopes and postage	50.70	
		$2 833.82
Office:		
Secretary's salary	$200.00	
Secretary's expense	20.60	
Assistant to Secretary's salary	1 080.00	
Assistant to Secretary's expense	159.19	
Substitute Assistant to Secretary	68.67	
Rent	687.50	
Printing, stationery, and postage	374.56	
Membership lists	283.67	
		2 874.19
Meetings and Committees:		
Stereopticon	$70.30	
Dinners	681.10	
Music	29.50	
Printing, stationery, and postage	328.75	
Badges	67.50	
Clerk at Albany convention	52.50	
		1 229.65
Treasurer's salary and bond		67.50
Certificates of membership		2.40
Miscellaneous		110.11
Dues of members in service		192.00
Flowers		10.00
Income tax		6.49
Engraving Brackett medal and cases		8.50
		$7 334.66

LEWIS M. BANCROFT, *Treasurer*,
In account with the New England Water Works Association.

RECEIPTS.

1919.			
Jan. 1.	Balance on hand		$2 957.03
	Received of Willard Kent, Secretary		8 144.05
	Interest on bonds and deposits		179.11
			$11 280.19

EXPENDITURES.

Bills paid		$7 334.66
BALANCE ON HAND.		
People's Savings Bank	$2 000.00	
Mechanics Savings Bank	481.65	
First National Bank	435.55	
Liberty Trust Company	1 028.33	
		3 945.53
		$11 280.19

ASSETS AND LIABILITIES.

ASSETS

Cash balance in banks		$3 945.53
Bonds Nos. 2642 and 2644 Lake Shore & Michigan Southern R.R. 4s, due 5–1–1931.		
Book value	$1 815.00	
November coupons	40.00	1 855.00
Accounts receivable:		
Advertising	60.00	
JOURNALS	2.00	
Meter rate sheets	1.00	
		63.00
		$5 863.53

LIABILITIES.

Accounts payable	$0.00
Surplus	5 863.53
	$5 863.53

BOSTON, MASS., January 12, 1920.

LEWIS M. BANCROFT, *Treasurer*.

Report of Auditing Committee.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers. The Treasurer has also accounted to us for the investments and cash on hand, as submitted in the above report.

GEORGE A. CARPENTER,
EDWIN L. PRIDE,
FRANK A. MARSTON,
Finance Committee.

The President. It would be unfair to the incoming administration to allow the impression to go out that all bills have been paid. Bills coming to the President after January 1, when the Secretary and Treasurer closed their books, so far have amounted to about $1 700, which included the printing of the Journal.

Report of the Editor.

January 14, 1920.

Mr. Henry A. Symonds. *To the New England Water Works Association:* I present the following report for the Journal of the New England Water Works Association for the year 1919. I would like to explain at this point that the figures in this report have largely to do with Volume 33 of the Journal; they do not correspond with the receipts and expenditures of the calendar year which have been given you by the Secretary and Treasurer.

The special issue containing the history of the 26th Engineers will be printed as a second section of the December, 1919, issue, and will include title page and yearly index, but is not considered in this report as it is largely essentially an extra.

The accompanying tabulated statements show in detail amount of material in the Journal.

Size of Volume. — The volume contains 727 pages, an increase of 170 pages from that of 1918.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge.

Circulation. — The present circulation of the Journal is:

Member, all grades	899
Subscribers	80
Exchange	23
Total	1 002

a decrease of 8 from the preceding year. Journals have been sent to all advertisers.

Advertisements. — There has been an average of 28 pages of paid advertisements, with an income of $1 863.75, an increase over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the

value of $18.90 have been sold. There were 293 copies printed, at cost of $43.95. Price has been advanced from 10c. to 25c. per copy. The net gain up to a year ago had been $322.15, so that the total net gain from this source to date is $297.10, and 273 copies of specifications on hand, $68.25 worth if sold at retail.

Proceedings.

The Association has a credit of $1.52 at the Boston Post Office, being the balance of money deposited for payment of postage upon JOURNAL at pound rates.

The following tables are for Volume XXXIII, not for the calendar year, and receipts and expenditures show total charges and accounts payable with no reference to amounts actually received or disbursed.

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXXIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1919.

Date.	Pages of								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
March	81	60	141	...	33	4	2	180	29
June	68	8	76	...	33	4	0	113	8
September	123	47	170	...	33	4	8	215	41
December	165	14	179	...	33	4	2	218	32
Total	437	129	566	...	132	16	12	726	110

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXXIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1919.

Receipts.		*Expenditures.*	
Advertisement	$1 863.75	Printing JOURNAL and mailing	$2 842.41
Sale of JOURNALS	129.00	Printing and preparing illustrations	950.49
Sale of reprints	39.20	Editor's salary	300.00
Subscriptions	261.00	Editor's incidentals	18.08
	$2 292.95	Advertising agent's salary and commission	116.50
Net cost of JOURNAL	2 675.04	Reporting	312.51
		Reprints	428.00
	$4 967.99		$4 967.99

TABLE 3.

COMPARISON BETWEEN VOLUMES XXIII TO XXXIII, INCLUSIVE (OMITTING VOLUME XXXI), NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.	Vol. XXX. 1916.	Vol. XXXII. 1918.	Vol. XXXIII. 1919.
Average edition (copies printed)	1 000	1 150	1 000	1 000	1 000	1 050	1 325	1 500	1 388	1 200
Average membership	710	732	752	740	745	803	904	1 002	954	902
Circulation at end of year	802	827	840	826	858	951	1 079	1 155	1 010	1 002
Pages of text	459	643	475	401	554	564	596	538	398	566
Pages of text per 1 000 members	646	880	632	542	746	702	659	538	417	627
Total pages, all kinds	627	808	654	567	733	719	776	707	557	726
Total pages per 1 000 members	884	1 090	870	766	984	895	859	707	584	805
GROSS COST:										
Total	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35	$3 386.63	$3 115.00	$4 967.99
Per page	4.97	4.32	4.02	4.37	4.89	4.65	5.47	4.79	5.59	6.84
Per member	4.39	4.78	3.50	3.35	4.81	4.17	4.68	3.38	3.26	5.51
Per member per 1 000 pages	7.00	5.90	4.09	5.90	6.46	5.80	6.02	4.79	5.85	7.59
Per member per 1 000 pages text	9.56	7.44	7.36	8.35	8.68	7.39	7.85	6.30	8.19	9.74
NET COST:										
Total	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09	$1 171.98	$694.50	$2 675.04
Per page	1.26	1.65	.54	.17	1.80	1.61	2.70	1.65	1.25	3.68
Per member	1.11	1.82	.47	.13	1.78	1.44	2.32	1.17	.73	2.97
Per member per 1 000 pages	1.78	2.25	.55	.23	2.42	2.00	2.98	1.65	1.31	4.09
Per member per 1 000 pages text	2.43	2.83	.98	.33	2.38	2.55	3.88	2.17	1.83	5.25

It seems to be " up to " the Editor at this time to present the rather serious financial status of the Association.

During the years of the war, we have lost a large number of members, but the inevitable additional cost of running the Association, and especially publishing the JOURNAL, is giving the officers and the Executive Committee a difficult problem to solve, in order to make expenditures come within the receipts.

The publishing of the JOURNAL is the large item to be considered, and there are two general methods of helping out the financial situation in our policy with reference to the JOURNAL.

The first is to curtail the publications, cut down all discussions to a minimum, and perhaps publish only a fraction of the papers presented. When it is considered, however, that an average of nearly nine tenths of the members of the Association who pay the dues are not able to be present at the meetings, but get their benefit through the JOURNAL, it does not seem that this is the proper solution, or that we can expect to maintain or extend our membership if this policy is carried out. It will be possible to make some minor economies which will not make the JOURNAL less valuable to the members, but the total amount to be saved in this way is not large.

The second method of solving this problem is to find means of increasing the revenue. It is probably possible to make some gain by advance in advertising rates, as we are informed by the best authorities that advertising rates, like everything else, are being increased, and that we are entitled to make an increase for this purpose. Additional price for subscription will give a slight help. It may, however, be necessary for the Association to consider an increase in dues in the near future, if it is to be the policy to publish the JOURNAL on the same lines as formerly.

Respectfully submitted,

HENRY A. SYMONDS, *Editor.*

THE PRESIDENT. You have all heard the reports of the Secretary, the Treasurer, and the Editor. What is your pleasure in regard to them?

(On motion of Mr. Charles W. Sherman, duly seconded, the reports of the Secretary, the Treasurer, and the Editor were accepted and placed on file.)

ADDRESS OF THE RETIRING PRESIDENT.

PRESIDENT KILLAM. The Association has added another page to its history of achievements through the work of its officers, committees, and members, in the advancement and exchange of knowledge relating to the construction and management of water supplies.

Many of you who have been attending these meetings for many years will recall the days when the membership was made up chiefly of superintendents of water works, men who had been raised from the ranks. They came to these meetings in order to learn how to solve particular problems

in which others had had experience, and in return they were willing to relate their successes or failures. Time has changed these conditions. The old-line rank-and-file water-works man is seldom seen at the meetings to-day, and if perchance he does attend he quietly slips into one of the rear seats and never a word comes from him. Is it because our papers have been too technical? I believe that, while the older members deprecate the fact that we do not have as many papers read to-day by superintendents of water works, yet they feel that the times have changed from the problem—which in the past was one of distribution, as there was plenty of good water in the earlier days—to one of quality as well as quantity. I believe that the superintendents feel much indebted to the highly trained men who have specialized in this line of work for the technical help that they have received through papers and committee work.

The Association has always been noted for the excellent work of its special committees, and the growth in influence and ability to benefit its members has been largely due to the reports and conclusions of these committees. In order to continue this successful work, the cordial cooperation and assistance of the general membership of the Association is necessary.

Our Association will grow according to the worth it is to the individual. Our JOURNAL, which has long maintained its reputation as the leading publication on water-supply matters, should be made more valuable to the average water-works man. The trade papers, who employ especially trained men, condense the articles presented in open meetings and the important information is available to our members long before the papers are printed in our JOURNAL. This is logical, and no criticism of the trade press is intended, as it is the chief aim of our Association to diffuse data of value to the water-works fraternity which cannot be any better and more quickly accomplished than through the trade publications. The JOURNAL should be strictly a water-works magazine. The papers should be well edited and blue penciled, and there should be an increase in the advertising. The committee on publication has an opening through the JOURNAL to collect and publish water-works papers and data which have not been presented in open meetings, and such information could therefore be obtained only through our publication.

Comparatively few people in any community appreciate the water-works officials and the many difficulties attending the successful management of their works. If we can convince these officials who are not members, that this Association does appreciate their services and is willing to share their burdens, I believe that there will be a decided increase in membership. We need new members, and you have adopted the recommendation of your Budget Committee to make a drive. An intensive drive will cost money. If we are to continue to grow and maintain our standing among the technical societies of our country we must make individual efforts.

Let us start the new year with the slogan, "Let every member get a member." Drives are all right. They get quick results, but I believe that the individual effort of each member is most desirable in order to increase our membership and still be healthy. The responsibility rests upon us. Will we not accept it and render the service?

The annual convention was held at Albany, N. Y., and was attended by 396 members and guests. The exhibits were interesting and instructive, and very artistically arranged. The literary program was excellent, and the meetings were well attended. The entertainments were very enjoyable and called forth many favorable comments. This last feature was handled by a committee from the Water Works Manufacturers Association, which has been seeking this privilege for ten years. The idea of allowing a man to spend his own money proved advantageous to the Association. I trust that future conventions may gain in size and influence.

I thoroughly appreciate the support and consideration of the officers during the past year, and thank the members for the courtesy and kindness they have all manifested toward me during my year as President, and I congratulate the Association on the loyalty of its members.

Let us ever bear in mind that we live in deeds, not in years, and that the New England Water Works Association can move onward and upward only by the hearty coöperation of every member. [*Applause.*]

Election of Officers.

The President. The next thing in order to-day is the report of the tellers.

Mr. Thomas E. Lally submitted report of tellers, and the following were declared duly elected for 1920:

President, Henry V. Macksey.

Vice-Presidents: Charles W. Sherman, Frank A. Barbour, Percy R. Sanders, Beekman C. Little, James H. Mendell, William W. Brush.

Secretary, Frank J. Gifford.

Treasurer, Lewis M. Bancroft.

Editor, Henry A. Symonds.

Advertising Agent, Henry A. Symonds.

Additional Members Executive Committee: A. R. Hathaway, Patrick Gear, David A. Heffernan.

Finance Committee: George H. Finneran, George A. Carpenter, Frank A. Marston.

The President thereupon declared the above-named gentlemen to have been elected officers of the Association for the ensuing year. Addressing Mr. Macksey, the retiring President said:

"It now gives me great pleasure to resign to you the chair and the gavel of the Association of the New England Water Works. I congratulate the Association in having elected you as President, and I trust that you will have as enjoyable a year as I have had during 1919." [*Applause.*]

Address by President Macksey.

Members of the Association: Although I knew that I should be called upon to speak, I have prepared no address for this occasion. You have had many long reports to listen to, and have some entertaining speakers for the day, and the hour grows late. You will have to listen to me many times during the coming year.

I congratulate myself not only on the great honor you have conferred upon me in electing me as your President, but also on my good fortune in having so many able men with me on the board of government. I speak not only for myself but for them when I say that we will endeavor to make the coming year as successful as Mr. Killam and his board have made the past year, a year when, under most discouraging circumstances, the President, with the assistance of his board, did very creditable work. On this board we have a new Secretary. That is a most important place, and we have a good man to fill it, and I hope he will give us as good and faithful service as has the retiring Secretary, who served many years faithfully, who did good work and had the respect and the confidence and the love of all those members who knew him. [*Applause.*]

The many problems that have been brought up incidentally, as these reports have been read to you, may be boiled down to the old, old questions of membership and money. The Association to be strong must have new blood and young blood put into it, and a steady stream should be coming in, else we old fellows, who are becoming slowly fossilized, will allow the Association to grow cold. We must have sufficient money in order to return to the members good service, service of which they may be proud and which may keep up the reputation which this Association has had, and has to-day, the world over.

As your Editor has just told you, you have a very serious problem before you in regard to your Journal. I do not believe that it will be necessary for us to cut the quality of the Journal, and probably not the quantity. We will have a good Journal or none, and we will pay for it. It is not an unusual thing to-day to be told that you must pay more money for what you have been getting, and it is rather difficult for us who are salaried men, superintendents, engineers, and others, to be called upon to pay ever-increasing prices for all the necessaries, as well as the luxuries, of life, while our incomes remain practically stationary.

For the man who is in business, who is represented here by our associate members, the conditions are a little more favorable, for, while he may not accumulate much more wealth, he certainly handles much more money. We do not intend to say to the associate member that we propose to place the load upon his back, we merely ask him to help us, and there is one way that he can help us and help us greatly without any expenditure of money, and that is in the procuring of new members. As you all know, each superintendent sticks pretty closely to his own town. He may see the

men in his trade or profession within a radius of a few miles, but that is all that he meets except those who are members and whom he meets when he attends these meetings. But I have noticed a few of the associate members who travel through the country selling goods to the cities and towns in which water-works men are located, have found new members for us, and it seems that they all should enlist and do that missionary work, because they go into a town the moment a new superintendent comes in, the moment a new city government comes in. It is their painful duty to get on the job at once and get acquainted.

My experience with the associate members is this, — I am always glad to see them come, and regret when they go. They are all good fellows, and the superintendents like them and take their advice and the knowledge which they pass along. Their judgment is good, their advice is good, and they are fair and honest, and do not try to fool us. If our associates will make it a point to try to help us extend the membership of this organization in cities and towns where we now have no members they will be doing more for us than they could do with money, because we need men even more than we need money. That is the one thing that to-day I ask the associate members to remember.

I would not have it thought that the load should be taken off the active members' shoulders. Will each one think it over? Don't you know some one man who is a good man — because it is good men we want — that you could induce to become a member of this Association? If so, will you go to the trouble and expense of bringing him down here once, show him what we have got, and induce him to join? That is the kind of work we want done. If you will all enlist actively in the campaign I think you can rely upon the board of officers to so manage your affairs that you will not be asbamed of the record of the Association for the coming year. We have a good record so far and a hard one to beat, and we will try to beat it. [*Applause.*]

Election of Honorary Member.

Mr. Samuel E. Killam. Mr. President, twenty years in a man's life is a long, long time. In talking to a man, recently, he spoke about his position and said, " I ought to get out of here and do something better; they are offering all kinds of inducements outside." I said, " Well, why don't you? " " Why," he said, " I have been here twenty years, now, and I don't like to make a change."

I think that is so with the water-works officials and engineers; they are in the positions that they have grown up in, and twenty years to them seems a long time, the best part of their lives.

But when you consider twenty years being secretary of an organization of this kind, — and those of you who have served as officers know what it means to prepare meetings, to get data to present at your meetings, and papers to publish in your Journal that will keep the standard as high

as it has been — any man that goes through this for twenty years and makes very few enemies is, to my mind, a wonder. And such you have had with you during the last twenty years.

Mr. Kent, your retiring Secretary, has been one who has been loved by all the members, and he has been a hard worker and a faithful worker, a credit to the Association and an honor to himself.

Your retiring Executive Committee recommends, and I so move, that Mr. Kent be made an honorary member of the Association, for the good and faithful work that he has done in the past.

(The motion is seconded by several members with applause.)

MR. CHARLES W. SHERMAN. Mr. President, while the motion has been informally seconded by many of the members, I want the honor of formally doing it. When I first became a member of the Executive Committee of this Association, Mr. Kent was made Secretary. He was then, as you know, a past president of the Association. I served with him for eight years as editor, and then found that I had to retire. Mr. Kent has stuck it out twice as long. I certainly want to appear as the formal seconder of that motion.

THE PRESIDENT. Gentlemen, you have heard the motion that Mr. Willard Kent be made an honorary member of this Association. Were it not for the fact that the President should not make a speech, I could spend considerable time adding to what Mr. Killam and Mr. Sherman have said in regard to the value and our appreciation of the services of Mr. Kent.

(The motion was unanimously carried by a rising vote.)

THE PRESIDENT. It gives me great pleasure, Mr. Kent, to declare you elected an honorary member of the Association. [*Great applause.*]

MR. WILLARD KENT. *Mr. President and Gentlemen:* I was too old to go to war, but this is as unexpected to me as the call on my friend on the left was to him a moment ago.

I thank you for your kind words and expression of good-will. One of the great advantages of being secretary is the opportunity afforded for meeting good fellows. As my duties are closed, the agreeable episodes stand out strongly in my memory; whatever there may have been of perplexities and annoyances is forgotten.

I think it is generally understood that the secretary's duties are to record the sayings of others rather than to talk himself, at least that has been my conception of them, and I will not deviate now.

I believe that in the thirty-seven years of your existence as an Association you have accomplished a very considerable measure of success in advancing the knowledge and promoting the interests of public water supplies. It is my earnest wish that in the future you may have a still greater measure of success, to be accomplished by the hearty coöperation and active participation of all the members, and that cordial relations of good-fellowship among you may ever continue. [*Applause.*]

Adjourned.

February Meeting.

Hotel Brunswick, Boston,
February 11, 1920.

The President, Mr. Henry V. Macksey, in the chair.

Announcement was made by Secretary Gifford of the deaths during the past month of R. Winthrop Pratt and Frank L. Fuller. The President later announced the appointment of Messrs. X. H. Goodnough, E. G. Bradbury, and George W. Fuller as a committee to prepare resolutions on the death of Mr. R. Winthrop Pratt; and Messrs. F. C. Hersey, Jr., John C. Chase, and George E. Winslow as a committee to prepare resolutions on the death of Mr. Frank L. Fuller.

The following, duly approved by the Executive Committee, were elected members: Patrick E. Kelly, Cambridge, Mass., civil engineer; W. G. Classon, Leominster, Mass., civil engineer; Robert E. Ferguson, Medford, Mass., water commissioner.

Secretary Gifford. Mr. President, your Executive Committee has recommended that Walter H. Richards, of New London, Conn., be made an honorary member.

The President. Gentlemen, you have heard the recommendation of the committee, and in relation to that matter I want to read you a short letter which I got from one of the old members:

Derry Village, N. H.,
February 7, 1920.

Mr. H. V. Macksey,
Woburn, Mass.

Dear Mr. Macksey, — Mr. Walter H. Richards, of New London, Conn., is the third in seniority of the present members of the New England Water Works Association. He has been the engineer and superintendent of the water works and sewerage system of that city since 1872. For several years he was the junior editor, and rendered valuable service to the Association in that way. He is now in failing health, and I think that his being made an honorary member and relieved from dues for the rest of his life would be a very graceful act. He was not a charter member but came in at the first meeting of the Association. This is written without his knowledge or suggestion and I trust will be received in the spirit in which it is written. All of the charter members have been put on the honorary list and many others who came in later than Mr. Richards. Hoping that you will bring this matter up at the next meeting, I am

Very truly yours,

John C. Chase.

I quite agree with Mr. Chase, and will be very much pleased to receive a motion to elect Mr. Richards as an honorary member.

Mr. Thomas McKenzie. Mr. President, I move that the recommendation of the Executive Committee be adopted and that Mr. Richards be elected an honorary member of this Association.

(The motion was duly seconded and unanimously carried.)

President Macksey brought up the matter of the lunch and submitted

sample menus of the $1.50 (now served) and the $2.00 luncheons. He stated that $1.50 was the minimum price charged at the Brunswick for luncheon and that prices at City Club were about the same.

At the American House a more liberal amount served for the same money — quality about the same, service and conveniences much below that at Brunswick.

Informal vote taken on preference of present priced or the $2.00 luncheon.

Fifteen voted in favor of continuing the $1.50 luncheon; eight voted in favor of the $2.00 luncheon.

MR. CHARLES W. SHERMAN. Mr. President, I have here a resolution which I have been asked to present:

"WHEREAS: The public works functions of the Federal Government are now scattered through nine separate departments and thirty-nine bureaus and services; and

"WHEREAS: This independent operation and competitive relation of like functions in a large degree renders the Government uneconomical and inefficient in its business conduct;

"BE IT RESOLVED, that the New England Water Works Association endorses the proposition to organize under one department the many and varied public works and engineering functions of the Government as provided for in the Jones-Reavis Bill (S. 2232, H.R. 6649);

"BE IT ALSO RESOLVED, that copies of these resolutions be sent to each New England Senator and Representative."

I move the adoption of the resolution.

(The motion was duly seconded and carried.)

THE PRESIDENT. At the last meeting the associate members were asked to use their endeavors towards advertising the good points of this Association and bringing in new members, either active or associate. *I am pleased to say that some of the associate members have started to work and have shown results, and we are very grateful, and hope that the good work will go on.* If any associate member needs application blanks, if he will just leave his card with either Miss Ham when he is up at headquarters, or with Mr. Gifford or myself, we will see that they are promptly forwarded to him.

Mr. Edward D. Eldredge, superintendent Water Company, Onset, Mass., presented a paper entitled, "Economy in Pipe Lines for Small Water Systems." The discussion was participated in by Messrs. D. A. Heffernan, H. J. Goodale, Geo. A. King, John C. Chase, Henry A. Symonds, Joseph A. Hoy, Samuel E. Killam, Patrick Gear, President Macksey, and Leonard Metcalf.

In the absence of Prof. George F. Swain, of Harvard University, who was to have presented a paper on "The Creation of a National Department of Public Works," Mr. Robert S. Weston read a paper on this subject.

Adjourned.

IRVING SPARROW WOOD.

Born in Providence, November 26, 1857, and was the son of the late Charles P. and Sarah S. Wood (*née* Robinson). Mr. Wood died October 20, 1919, in the old homestead where he was born and lived since childhood.

Mr. Wood in his earlier years attended the common schools of Providence, and later went to Mowry and Goff's English and Classical School, from which he was graduated in 1877.

After his graduation he entered the city engineer's office in Providence, as a student in civil engineering. The first work to which he was assigned was assistant on bridges and on the Brook Street improvement scheme under Mr. Henry B. Francis.

Mr. Wood was employed in the various engineering departments, being assigned to the Water Department under the late Edmund B. Weston. At the time of Mr. Weston's resignation from the city engineer's office, May 1, 1894, Mr. Wood succeeded to the position of assistant city engineer, in charge of the Water Department, where he remained until his death.

Mr. Wood was elected a member of the New England Water Works Association on March 8, 1905; of the American Society of Civil Engineers, March 6, 1906; of the Boston Society of Civil Engineers on December 20, 1899, and of the Providence Engineering Society, April 30, 1918.

His general health began to fail the last year of his life, but he attended to his duties faithfully until October, 1919, when heart trouble developed and the end came.

In October, 1903, Mr. Wood was married to Miss Margaret E. Reed, who with an only sister survive him.

Although not a member of the Union Congregational Church in Providence, he made that his home church, where he was loved and respected for his upright character and cheerful disposition.

GEORGE H. LELAND.
SAMUEL M. GRAY.
FRANK E. WINSOR.